THERMAL INSECT CONTROL

MTDC Project

TA&S#4E32P11

1994

USDA Forest Service

Missoula Technology &
Development Center

Missoula, MT 59801

Send Copy to =
Alex Mangini
Dave Overhulser
Chuck Masters
Roger Sandquist

FY 94 - Progress Report

Thermal Insect Control
TA&S #4E32P11

Missoula Technology & Development Center
Keith Windell, Project Engineer
August, 1994

Contents

Background

At this time the "Thermal Insect Control" project is oriented towards tackling two different seed and cone insect problems found in Federal seed orchards. The tasks required to solve each problem are slightly different. The first is to raise the temperature at the litter/soil interface to kill overwintering Douglas-fir cone gall midges before they emerge. Professor Schowalter from Oregon State University has conducted lab experiments with midge larvae and obtained 100% mortality with a temperature of 100C for 15 seconds (dry conditions). He obtained 87% mortality with a temperature of 200C for 15 seconds followed by 80C for 20 seconds (moist conditions). The difficulty of this task in an orchard setting is highly dependent on fuel moisture, depth of organic layer, soil moisture, composition of soil and vegetation, and compaction of the soil.

The second task is to raise the internal temperature of a white pine cone to kill overwintering white pine cone beetles before they emerge. 50C was set as the target temperature based on input from Fire Forester Dale Wade (SE Forest Experiment Station). The necessary duration of this target temperature to obtain the desired effect is not known. The condition of the infected cone is typically closed (about 3" long and 1 1/2" dia.), dead, and with moisture content varying up to 195%.

Federal seed orchard managers have recently investigated the use of agricultural weed burning equipment (flamers) to accomplish the two tasks previously described. Two distinct efforts have taken place. One at the Beaver Creek Seed Orchard (BCSO) in Corvalis, Oregon in which the target pest was the Douglas-fir cone gall midge and the other at the Oconto River Seed Orchard (ORSO) outside of Shawno, Wisconsin in which the target pest was the white pine cone beetle. Keith Windell from MTDC was able to attend equipment evaluations at each of the locations (April/May 94). The Beaver Creek flamer equipment was a prototype field burner loaned by Rears Manufacturing (Eugene, OR). The Oconto River flamer was a commercially available agricultural weed burner purchased from Thermal Systems Inc. (Neillsville, WI). Trip reports have been previously submitted. At the time that the trip reports were written it was not known if either treatment was successful. Degree of success was to be determined later by entomologists monitoring insect survival.

Results

Beaver Creek Seed Orchard

Professor Schowalter has indicated (pers. comm., 1994) that the monitoring of cone gall midge survival by the use of emergence traps on the BCSO flamer trial was unsuccessful. No data which could be used to interpret the effectiveness of

the weed burner approach was collected. Professor Schowalter indicated that examination of the litter/soil temperature profiles generated by the test burn shows that the flamer system as tested was not successful. Temperature profiles are included in the appendix.

When the flamer was operating at tractor crawl speed over 1/2" thick duff, the temperature at the litter/soil interface was basically unaffected by the heat source. When the flamer was stationary, 200C was reached in about 20-25 seconds at the litter/soil interface. With the site pretreated by a modified flail mower (0"- 1/8" vegetation left) and with the flamer crawling along, neither of the temperature sensors at the litter/soil interface exceeded 30C. In another flail mowed/flamer test at tractor crawl speed, neither temperature sensor under the duff exceeded 55C. When the flamer was stationary over a flail mowed spot it took about 25-30 seconds to raise the temperature to 200C under the moist residual duff layer. In areas where all duff was removed, the soil exposed insects would be incinerated quickly if not minced by the flail hammers. When looking at the temperature profiles keep in mind that some of the apparent delay in litter/soil heating is due to instrument response time lag.

If the flamer at BCSO could be intermittently dragged and parked about every 10 feet for a duration of 20-30 seconds the desired efficacy might be achieved. This could be done with a winch mounted on the tractor. The propane tank would have to be mounted on a small trailer preceding the burner (for safety) and steel wheels would have to be substituted for the rubber tires on the burner.

Funding for the BCSO effort has been extended one more year and this group is interested in additional testing with a combination of modified flail mower and flamer treatments. This fall Professor Schowalter (OSU), Bill Randall (Siuslaw N.F. Area Geneticist), and Kim Brown (BCSO) intend to conduct a prescribed burn in the orchard to reduce the litter layer. More testing will take place in the spring. The emergence traps will be put out again to monitor insect survival after the treatments next Spring.

Oconto River Seed Orchard

Steve Katovich, entomologist from the Northeastern Area, dissected and analyzed white pine cones from the ORSO flamer trials. His report is located in the appendix. Results from the tree breeding arboretum ranged from 5% beetle survival (check: 85%, fuel moisture content: 13%) to 67% beetle survival (check: 59%, fuel moisture content: 195%). The 10 acre operational burn had 19% beetle survival (check: 83%, cone moisture content: 11%) at a cost of $147 in fuel (245 gallons of propane) and was accomplished in 11 hours with 7 people. Steve is not satisfied with the erratic results and is interested in having MTDC come up with a

more effective method. Steve has mentioned on the phone that there may be another test burn in the Spring. In his report Steve has noted that:

- Fine fuels and cones must be dry to obtain adequate control. This reduces the window available for treating orchards and increases the fire hazard. A specific minimum fuel moisture necessary for control has not been determined.
- Fire behavior becomes much more manageable once green-up begins.
- The lethal temperature for cone beetle control should be reexamined. The flamer appeared to apply intense heat and in addition caused ignition of most fuels, yet control in most cases was not extremely good.
- A number of adjustments involving increasing pressure and burner angle tested to attempt to improve the efficacy of the flamer.

Possible Project Approaches

After reviewing the project objectives and the initial efforts by the two seed orchards, several different approaches for future project direction come to mind:

- Instrument both orchards to determine how close flamer equipment and future alternatives come to the desired temperatures. Beaver Creek would need thermocouples placed at the litter/soil interface. Oconto River would need their infected cones instrumented with thermocouples. The Intermountain Fire Sciences Laboratory in Missoula has recommended we use 24 gauge, glass insulated, thermocouple wire with welded ends for our tests. It may be possible to borrow CR10 dataloggers from MTDC if there are no conflicts with the FPM spray program. There are melting indicators (Tempills) and paint strips which indicate when specified temperatures are reached but neither indicate the duration of the temperature.

- Proceed with mower/flamer treatments as planned in the Spring at the Beaver Creek Seed Orchard. This may solve their problem if enough insects can be minced or brought into close proximity to the passing flames.

- Monitor performance of prototype hooded burners (Thermal Weed Control Systems, Inc.) if they are tested on the Oconto River Seed Orchard. If they are effective purchase a unit for the Beaver Creek Seed Orchard ($5000).

- Install steel wheels on the burning unit at the Beaver Creek Seed Orchard. Mount a winch on the back of the orchard tractor. Rent a larger propane tank and mount it on a small trailer ahead of the burning unit. A cultivator could be mounted on the trailer (to open up the duff layer) before the flamer. Pull the trailer and burning unit with winch up and down the orchard in an intermittent fashion.

- Test steam generating equipment currently being purchased by MTDC for a nursery project as a possible replacement for methyl bromide (used for soil sterilization). Steam will be transmitted to soil by an undercut bar 10" below the surface. This configuration will not work in this application so we will have to design and build our own injection system. (Possibly a cultivator with steam ports pointed rearward.)

- Test "Hot Inplace Asphalt Recycling" machinery in an orchard to get a more intense heat source of longer duration. This equipment is used by the road construction industry to refurbish asphalt pavement. We would only need to utilize the preheater portion of the "train". The equipment is very costly and would need to be operated by the contractor. Pacific Pavement Recycling, Inc. has a machine built by Pyro-Tech and is willing to check out a possible contract at the Beaver Creek Seed Orchard. Pyro-tech uses an open flame oriented horizontally in an enclosed chamber. Wirtgen is another company which makes use of infra-red technology in their equipment. We would have to pay for round trip equipment transportation from Seattle, WA and guarantee 40 hours of work at $230 per hour ($9200). Again white pine cones could be imported from Wisconsin for testing. There is a company called Burners, Inc. which may be able to fabricate a scaled down version of the equipment for us (many $).

- Adjust burning angle of nozzles on the Oconto River Seed Orchard burning device and retest. Repeat with different angles. Vary speed of tractor.

- Enhance existing burning equipment at the Oconto River Seed Orchard by installing prototype hooded burners made by Thermal Weed Control Systems, Inc. This would allow more time for the cones to be exposed to the high temperature. A picture of a similar device is in the appendix. A mock-up could be demo'ed this winter by the orchard. Five 27" wide hooded burners could be purchased and attached to the existing frame for $1000 and a little frame modification. An entire new unit (minus the propane tank) could be had for $4500-$5000 and be ready for the Spring burn.

- Sweep infected cones at the Oconto River Seed orchard into a wind row using a sweeper from the nut growers industry. Pick up the cones with a nut harvester and transport to a remote location for pest destruction by burning or drowning. They are looking for some older nut harvesting equipment for us that can be refurbished and possibly used. No cost estimates are available on this approach yet. Weiss/McNair also manufactures a special order pine cone harvester. Here we are talking about $22,000+. The Flory Company has offered to sell us a stripped down P.T.O. harvester for $5,800 and a used

sweeper for $11,000 (fob Salida, California). They state that if it doesn't work they will buy back the equipment. Ramacher offers a nut sweeper for about $27,000 and a nut harvester for about $23,000. They have offered to lease the equipment necessary to test the concept for a one month (minimum) lease of about $20,000 (fob Linden, California).

- Test steam generating equipment previously mentioned to treat the white pine cones in the Oconto River Seed Orchard. Perhap a steamer box could be built and dragged behind the steam generator. A crude sketch of this type of box is included in the appendix.

- Microwaves are an alternative which upon closer inspection is not advisable. They have been used successfully to inhibit the germination of weed seed. There have been attempts to use microwaves to sterilize soil but it is still in the experimental stage. The OI Corp. (with advice from Texas A&M) once built a machine called the "Zapper" which utilized a "horn" under the soil to transmit the microwaves. It is no longer available. There have been safety concerns mentioned with this approach - related to misdirected microwave radiation. Professor Jim McDonald at U.C. Davis is currently investigating microwaves to treat soil. One company contacted (Microdrive) mentioned we need to operate in the 915 MHz range to get the penetration we desire (home microwave machines operate in the 2450 MHz range). To illustrate the significance of this statement they suggested I put a fly in a home microwave machine. They claim the mass of the fly is too small and the fly will not be killed. I have not verified this myself. They also said that water absorbs the microwaves. If the soils (or cones) are dry the moisture in the insects might improve efficacy. They seemed to think that at the time of the year we want to kill the insects most microwaves will be absorbed by the ground since moisture is present. I was not able to locate any off the shelf equipment to do what we need. We would have to launch a major development effort to pursue this concept (many $).

- Another scheme which was suggested and put on hold was to cover the orchard floor with visqueen thus raising the soil and cone temperatures through solar heating. The plastic would have to be installed after the pests had migrated to the orchard floor and after all orchard management practices had stopped for the winter. The trees could not be worked on until the plastic was removed.

Discussion
The previous attempts at thermal insect control at the BCSO and the ORSO have not produced the desired effect. I think the BCSO stands a good chance of success if they reduce the duff layer with a prescribed fire in the fall (as they plan to), flail mow in the spring and use the flamer after the flail mower. It may even work better if a little time for the flailed duff to cure passed before using the flamer. Hopefully the ORSO will test a prototype hooded burner made by Thermal Weed Control Systems, Inc. If it looks good I would like to purchase one for the BCSO. Another approach would be to modify the movement of burner down the orchard rows to allow more time for the heat to penetrate the duff layer. A winch on the back of the tractor could be worth trying The next step up would be to try the steam injection system being put together for a soil sterilization project at the Coeur d' Alene Nursery. An injection system such as a modified cultivator would have to be designed and built. As a last resort a contractor using a asphalt recycling preheater could be tried.

It is hard to know exactly how close the equipment was to obtaining the target core cone temperature at the ORSO because cones were not instrumented. I think it is important to know what the fuel moisture and core cone temperature is every time the burner is used. Then if a technique is proven to be successful, guidelines for equipment usage can be developed (i.e. Don't burn if cone moisture content is above 40%; tractor must be driven in 1st gear at 1500 RPM). An instrumented test pass prior to an operational burn may even indicate that the flamer can travel faster which will decrease the the cost of treatment.

If success at ORSO cannot be obtained by redirecting the angle of the burner nozzles or slowing down the tractor then there are other options. Purchasing and testing the prototype hooded burners made by Thermal Weed Control Systems, Inc. would be worth while. These burners would heat the cones more efficiently and provide more time for the core cone temperature to rise. The advantage of this approach is that the orchard already owns the propane tank. In addition, existing equipment may be modified for use with the new hooded burners. The drawbacks to this approach are that propane is still burned and a fire holding crew is still required.

There are two other interesting alternatives which seem reasonable - cone removal and steam injection. Both of these would be more expensive up front but would be favored if smoke pollution becomes a primary concern (It does not appear to be at this time).

The cone removal approach may turn out to be cheaper to use. The technique is desirable because it reduces man hours (no holding crew around the perimeter), no

propane is burned, and it is safer (no escaped fires or burned workers). Whether it is more cost effective is yet to be determined. Sounds good - the question is how well will the harvester pick up the cones and how much time will it take.

To test the steam injection concept at the ORSO a steamer box would have to be designed and fabricated. This approach has the advantage of no open fire to escape. Disadvantages include the fact that propane fuel is still burned, and it requires a larger equipment turning radius than the flamer.

Recommendations

FY 95

1. Attend next flail mower/flamer test at Beaver Creek Seed Orchard (BCSO). Provide data logger support (borrow or purchase).

2. If prescribed fire/flail mower/flamer test at BCSO is unsuccessful: Consider purchasing Thermal Weed Control Systems, Inc. prototype hooded burner system ($5000). Test concept in Fall (Insects would be long gone but the temperature profile could be generated. If results are encouraging test equipment on the next insect cycle).

3. If prototype hooded burner system is not pursued work with BCSO orchard personnel to modify the way Rear's flamer is used. Purchase and attach winch to orchard tractor. Purchase and mount steel wheels on flamer unit. Purchase trailer and modify if necessary. Rent larger propane tank. Instrument orchard. Test concept in Fall (Insects would be long gone but the temperature profile could be generated. If results are encouraging test winch concept on the next insect cycle).

4. Have Oconto River Seed Orchard (ORSO) evaluate mock-up prototype hooded burner from Thermal Weed Control System, Inc.. If it looks good purchase replacement burner system ($5000). Shake down test of equipment by orchard in anticipation of Spring test. Make equipment modifications if necessary.

5. Attend ORSO Spring test. Instrument infected cones if possible. Adjust nozzle angle and monitor temperature history to determine optimum angle. Vary tractor speed. Attach prototype hooded burners and test.

6. If nozzle angle adjustments, or slowing down tractor, or prototype hooded burners are unsuccessful at ORSO take series of site visits to view operation of nut harvesting equipment for possible purchase.

FY 96

1. Retest Thermal Weed Control Systems, Inc. prototype hooded burner equipment at BCSO (If developed in FY95). Check insect mortality.

2. Retest winch concept with modified Rears' flamer in Fall at BCSO (If developed in FY95). Check insect mortality.

3. If protoype hooded burners and modified Rear's flamer are unsuccessful at BCSO: Design steam injection system to be used with steam generator.

4. Purchase refurbished Weiss/McNair nut harvesting unit for ORSO if it looks good (and the price is right) or purchase their cone harvester for $22,000+. Flory has an offer which should be considered also.

5. Test cone removal concept at ORSO. Check insect mortality.

6. If cone removal is unsuccessful at ORSO: Design steamer box to be dragged behind steam generator.

FY 97

1. Fabricate steam injection system to be dragged behind steam generator at BCSO. Test in Orchard. If temperature profiles look good test with insects next Spring.

2. Fabricate steamer box to be dragged behind steam generator at ORSO. Test in Orchard. If temperature profiles look good test with insects next Spring.

FY 98

1. Test steam injection system at BCSO in Spring. Check insect mortality.

2. Test steamer box to be dragged behind steam generator at ORSO in Spring. Check insect mortality.

3. If all previous attempts are unsuccessful (by the end of FY97) test asphalt preheating equipment (This would probably always have to be done on a

contract basis because of the price of the equipment involved. Although we will probably test the preheater's effect on white pine cones imported from ORSO results may not matter because we will have a tough time convincing a company to travel to Wisconsin for such a small job. Not many companies have this type of equipment and I have asked all that I know of.)

4. Project record.

Appendix

Report from Professor Schowalter / Temperature Profiles

Annual Report to
National Steering Committee on Management of Cone, Seed and Regeneration Insects

T.D. Schowalter
Entomology Department
Oregon State University
Corvallis, OR 97331-2907

This annual report describes a cooperative effort with Roger Sandquist, Bill Randall and Pete Owston (U.S. Forest Serv.) to evaluate the effectiveness of litter flaming as a means of controlling Douglas-fir cone gall midge, *Contarinia oregonensis* Foot, and Douglas-fir seed chalcid, *Megastigmus spermotrophus* Wachtl, in seed orchards. These insects are the two most destructive species associated with reduced seed yields in Douglas-fir seed orchards in western Oregon. Because of their cryptic habits, few non-chemical tactics for controlling populations of these species are available. However, their habit of overwintering in litter under host trees makes them vulnerable to litter treatment such as burning.

Initial assays in the lab indicated that midge larval mortality increased as temperature and duration of heat exposure increased and was maximized under dry conditions. Subsequent efforts to achieve these lethal temperatures at the Beaver Creek Seed Orchard during winter and spring 1993-94 were unsuccessful. Wet litter conditions prevented burning during much of the period, and flaming trials achieved maximum surface temperatures of up to 200° C but temperatures at the soil surface under litter were unchanged (Figs. 1-3). We modified our experimental plan by adding a preliminary step to pulverize and dry the litter using a standard flail chopper, but wet conditions continued to prevent heat penetration below the litter surface. Our plan for next year calls for litter treatment in fall to minimize available habitat for midge larvae.

Publications

Schowalter, T.D. 1994. Cone and seed insect phenology in a Douglas-fir sed orchard during three years in western Oregon. J. Econ. Entomol. 87: 758-765.

Schowalter, T.D. and G.M. Filip. 1993. Beetle-Pathogen Interactions in Conifer Forests. Academic Press, London. 252 pp.

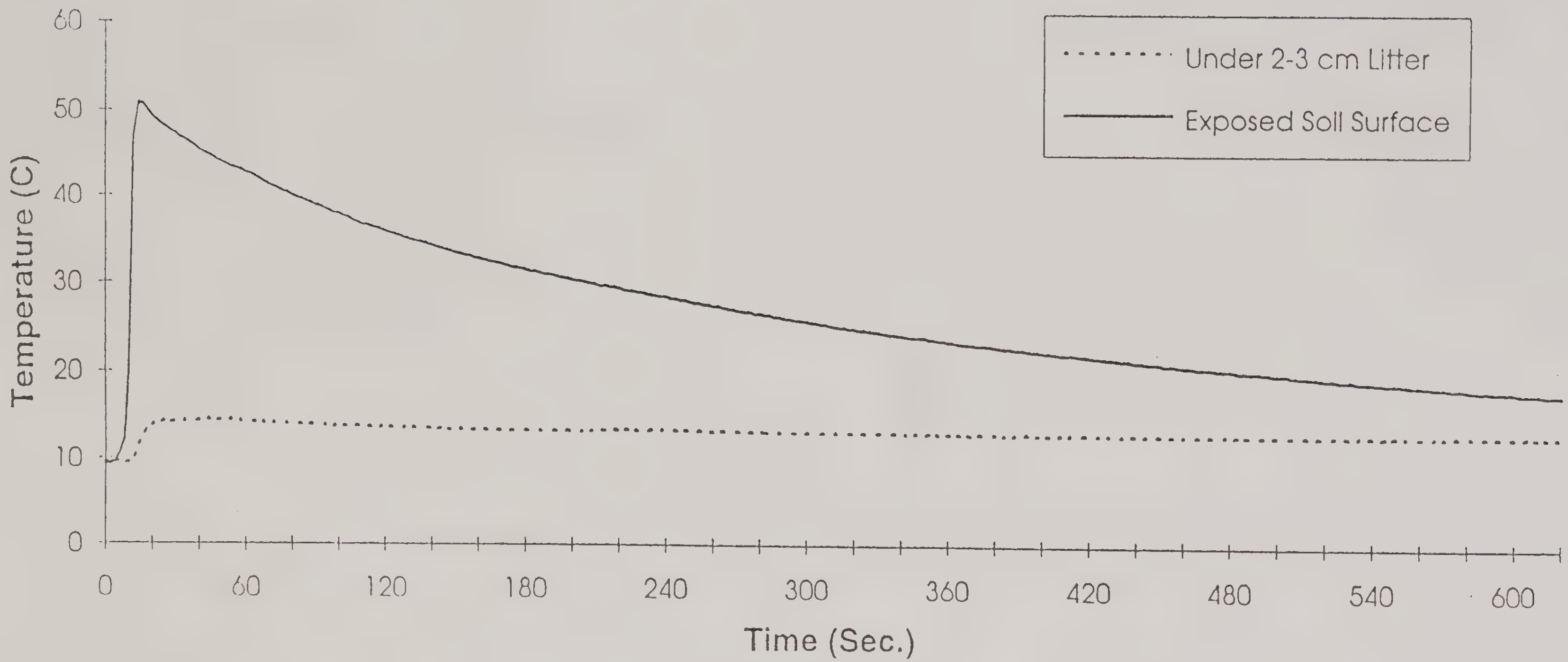


Figure 1. Temperature profile from flaming unchopped litter at Beaver Creek Seed Orchard during January 1994

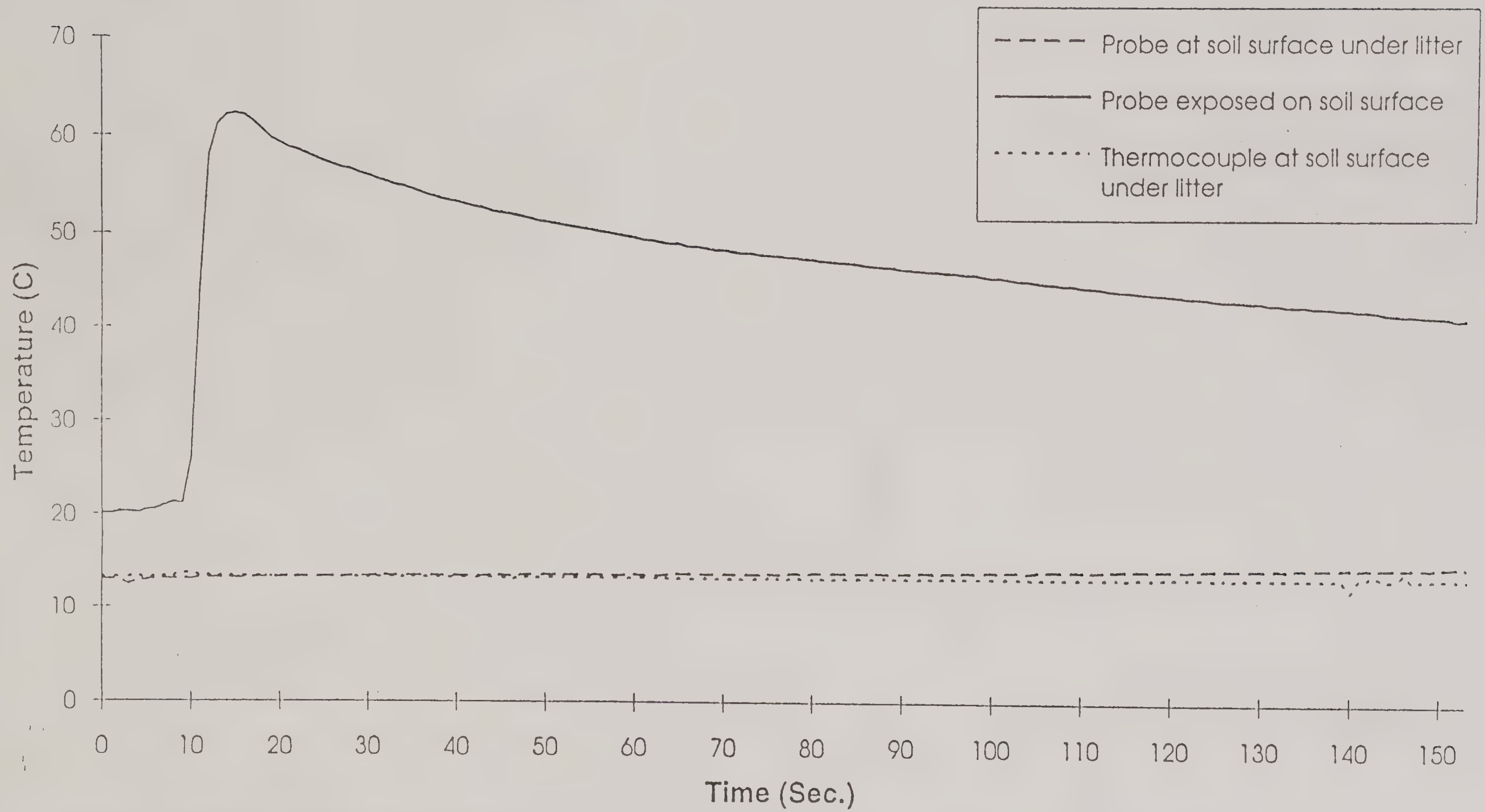


Figure 2. Temperature Profile from flaming unchopped grass at Beaver Creek Seed Orchard In April 1994

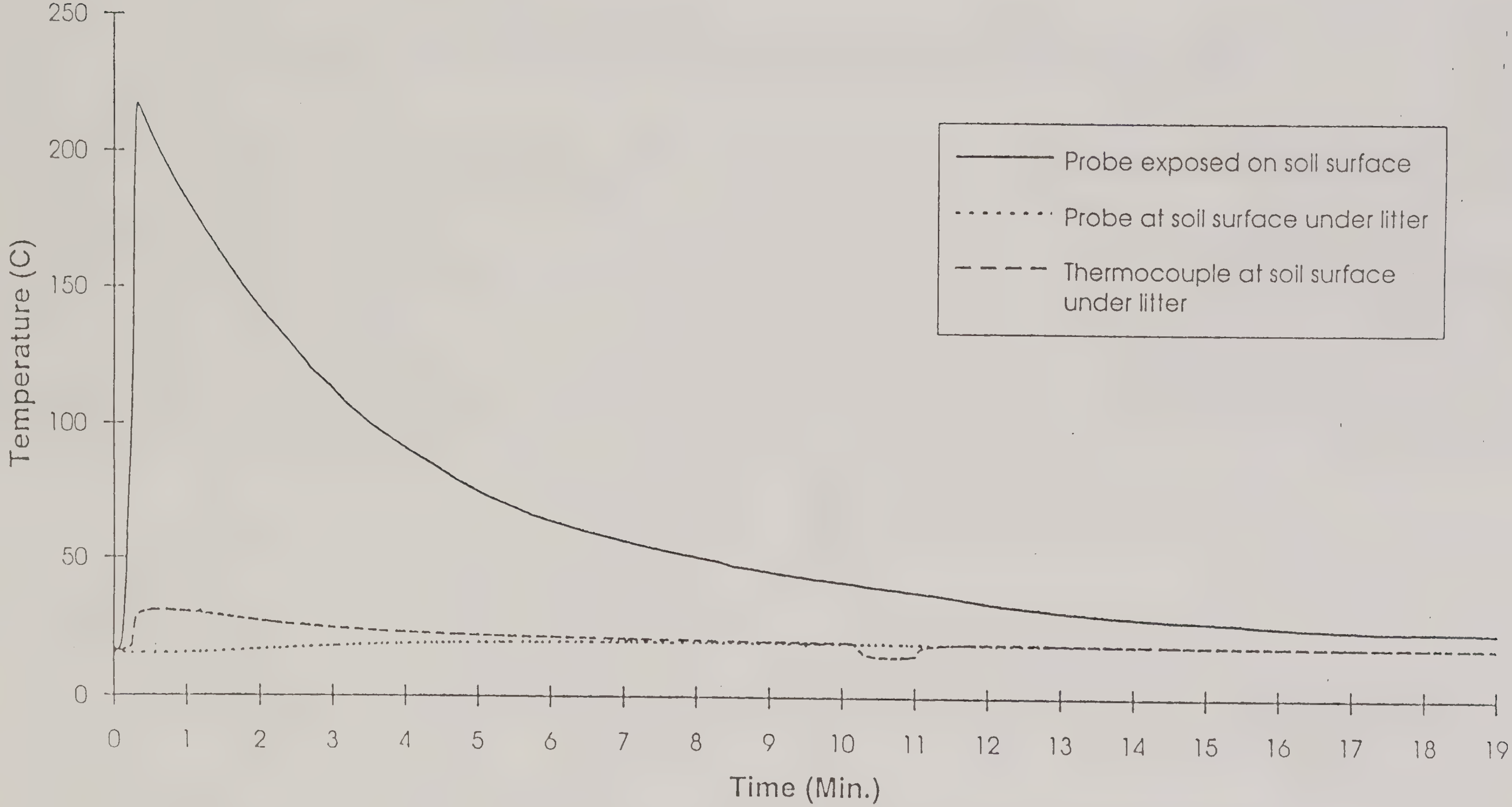
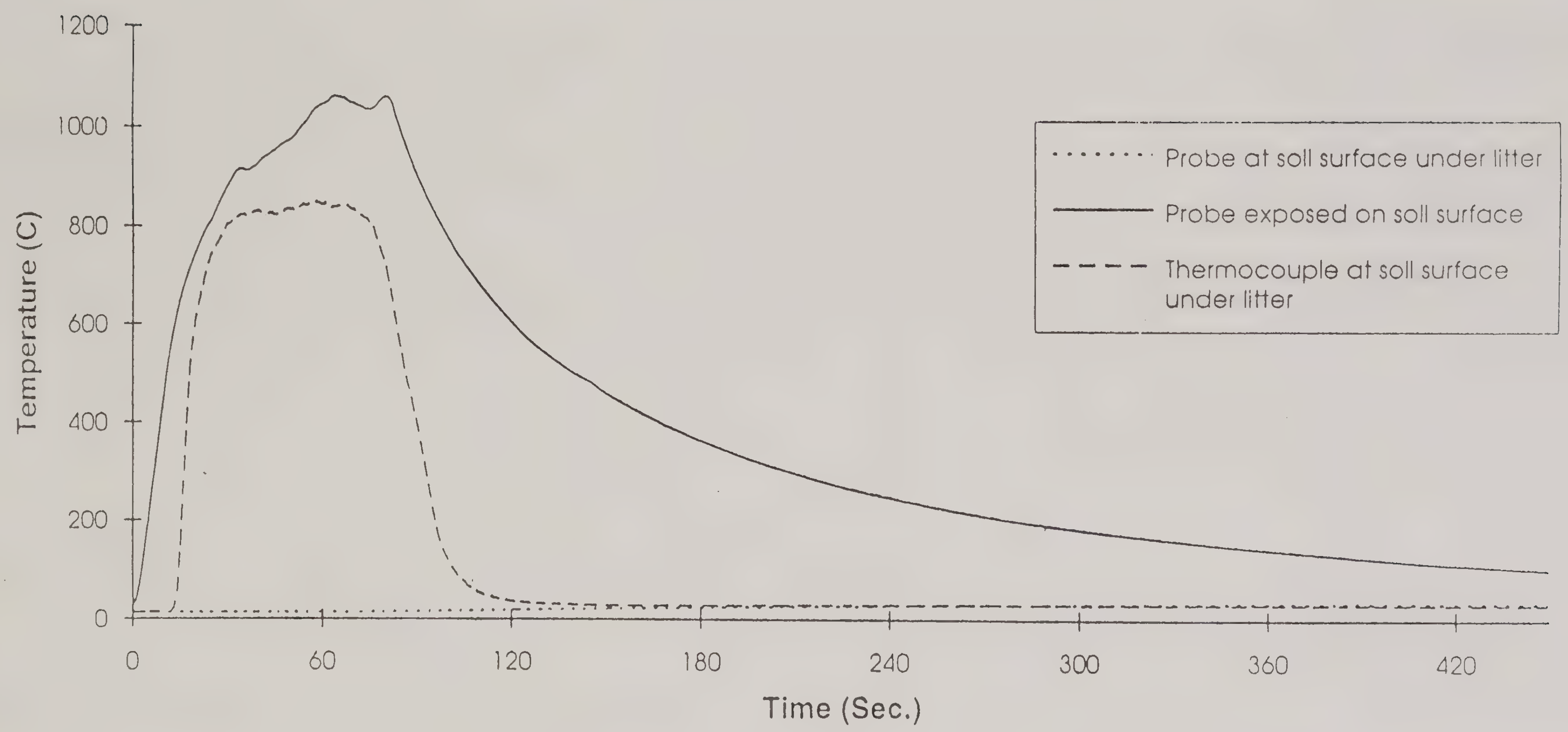
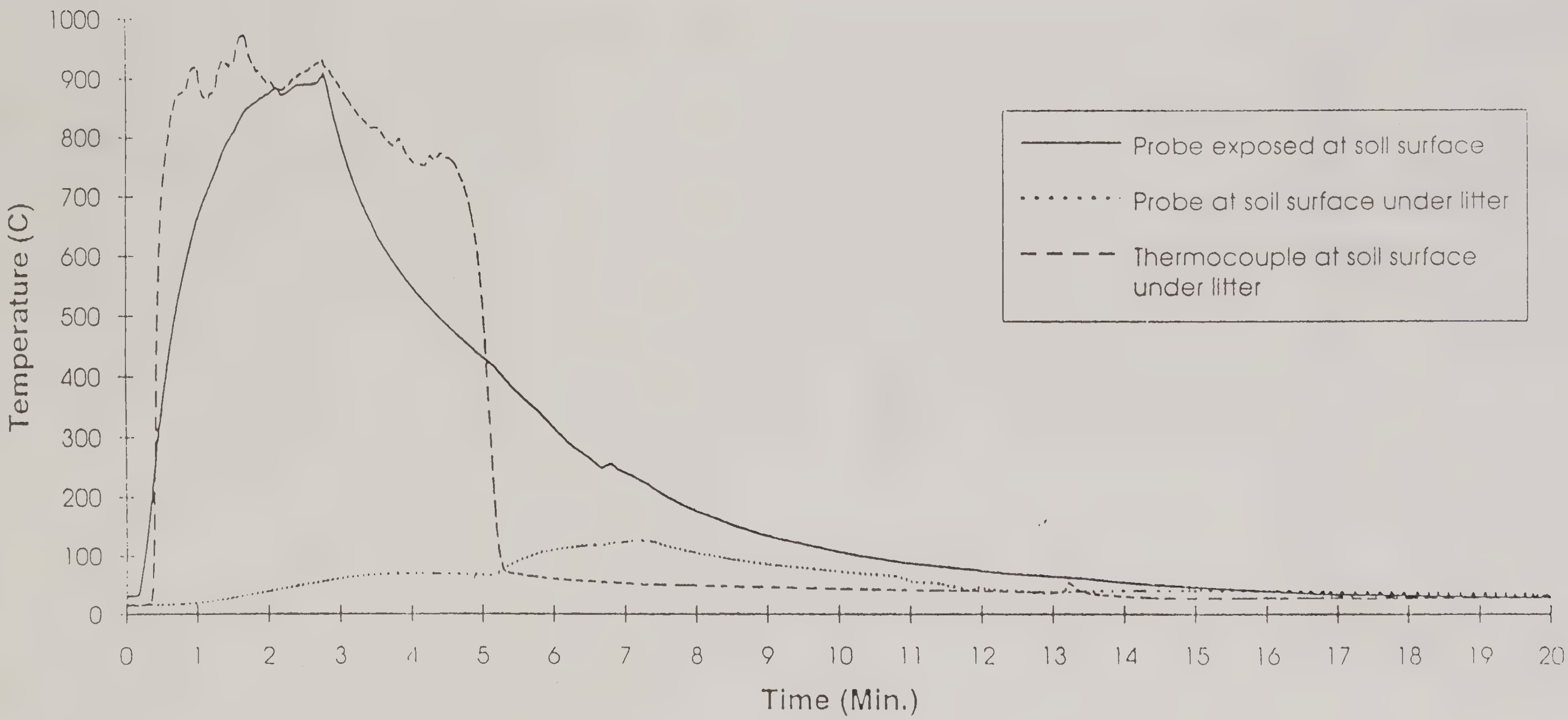


Figure 3. Temperature profile from flaming chopped grass at Beaver Creek Seed Orchard in April 1994

Temperature Profiles from Stationary Flamer over Unchopped Grass



Temperature Profiles from Stationary Flamer over Chopped Grass



Report from Steve Katovich

Operation of a Propane Flamer for Control of White Pine Cone Beetles in a Seed Orchard

Steven Katovich
USDA Forest Service
Northeastern Area

William Sery
USDA Forest Service
Oconto River Seed orchard

DRAFT

Introduction

The white pine cone beetle, *Conophthorus coniperda* (Schwarz) is the most destructive seed and cone insect of eastern white pine, *Pinus strobus* L.. Losses approaching 90-100 percent of a cone crop have been reported (Graber 1964, Wade et al. 1989). Therefore, suppression of cone beetles has been required in many seed orchards in order to obtain a seed crop. Satisfactory control was reported using the systemic insecticide carbofuran (Furadan[R]) (DeBarr et al. 1982). However, this insecticide is no longer available for use in pine seed orchards and other insecticides have not been reliable in controlling the white pine cone beetle. The lack of available insecticides and the general concerns that exist with insecticide use, have made the search for non-chemical control alternatives a high priority.

White pine cone beetles initiate attacks on cones in the early spring. Female beetles construct an egg gallery in the axis of a developing cone. Infested cones die and eventually drop to the ground. Larval development and pupation is completed within cones during the summer and the new adults remain in the infested cones until the following spring. The presence of infested cones on the ground provides an opportunity to directly kill beetles using fire. Prescribed fire has been successfully used to control cone beetles in red pine (Miller 1978) and in white pine seed orchards (Wade et al. 1989). Wade and others suggested that white pine cone beetles can be killed by a low intensity fire that scorches the cones and raises the internal temperature past a lethal threshold of 40-50°C.

Unfortunately, regular use of prescribed fire in a seed orchard has several drawbacks, including:

1) A short "window" in which to successfully conduct a burn. This is especially true in northern locations, such as in Wisconsin, where early spring fire danger ratings often go from very low to very high. At one extreme fuels are too wet to burn and at the other extreme, fuels and conditions make burning hazardous.

2) Annual prescribed fires can reduce fuel loads below what is needed for conducting a successful burn. Infested cones are scattered throughout an orchard and a rather "complete" burn is necessary for control.

Thus, what is needed is a technique that lengthens the burning window and provides complete heat coverage of the forest floor even when fuel loads are small or fuel is scattered.

This study investigated the use of a propane flamer mounted on a tractor as a means of applying intense heat to the forest floor in a seed orchard. Propane flamers have been used to successfully control insects and weeds in agricultural fields (Moyer 1992) and the technique and technology should transfer to seed orchard with minimal modifications.

Methods

A pre-assembled propane flamer unit (Thermal Weed Control Systems, Inc.) was used. The unit design consisted of 8 individual liquid burners. The burners and 100 gallon tank were mounted on a 3-point hitch. Burners were ca. 18 inches apart and were operated ca. 10 inches from the surface of the duff layer. The unit was equipped with an automatic ignition system.

The burner was field tested in spring, 1994, at the U.S. Forest Service, Oconto River Seed Orchard (ORSO), located on the Nicolet National Forest in northeastern Wisconsin. ORSO is not a single seed orchard, but, rather a complex of several seed orchards and breeding arboretums of different species. ORSO contains two blocks of eastern white pine, one 10 acre orchard and one 20 acre breeding arboretum. In both locations, trees are spaced ca. 20 ft x 20 ft apart. Trees are ca. 30 ft. tall. Terrain is flat, and both areas are mowed regularly and trees are pruned to a height of ca. 10 ft. The past two years, cone production has been heavy in both the orchard and arboretum. Populations of white pine cone beetles have been present in both areas.

Field trials conducted in 1994 consisted of two components, a series of plot trials and an operational trial.

<u>Plot trials</u>: Plots trials, made up of individual treatments, were conducted in the arboretum. Treatments consisted of the propane flamer unit operated at 3 or 4 different speeds, crawl, slow, medium and fast. These speeds were based on gear settings on the tractor. An untreated check treatment was included on each trial date. Each treatment was done on a plot that was 200 ft in length and 12 ft in width, the width of the flaming unit. All treatments were replicated six times between 6 April and 12 May, 1994.

Moisture content as percent oven dried weight of both cone beetle infested cones and fine fuels was recorded for the time and date of each trial. Fuel loading was calculated by collecting all

material in a ft^{2}, down to the soil layer. Five random ft^2 samples were collected. This material was weighed, a mean weight was calculated, and multiplied by 43,560 to obtain a per acre fuel load in tons/acre.

Following treatment, percent survival of cone beetles was calculated within each plot. A minimum of 25 cone beetle infested cones were collected from each plot, dissected and live and dead beetles recorded.

Operational trial: A simulation of an operational project was conducted in the 10 acre orchard on May 3 and 4. The propane flamer unit was operated at the medium speed. Fuel moisture content was recorded during the operation. Both pre- and post-burn cone samples were collected, 30 cones each, to compare percent beetle survival. Fuel use and time necessary to complete the project were documented.

Fuel loading was calculated by collecting all material in a ft^{2}, down to the soil layer. Five random ft^2 samples were collected. This material was weighed, a mean weight was calculated, and multiplied by 43,560 to obtain a per acre fuel load in tons/acre.

Results

Plot trials: The initial trials on 6 and 13, April, were conducted with extremely wet fuels (Table 1). Snow was still present under the orchard trees and on 6 April, the cones were still frozen on the inside. Air temperature during the 6 April treatments was 36° F. The propane flamer operated well. Fire behavior was minimal and in fact, snow melt did not even occur following burner application on the 6th. Beetle kill was minimal (Table 1).

The field trial conducted on 21 April, was conducted under very dry conditions and extreme fire hazard. Fuel moisture of cones was estimated at 13% (Table 1), and RH was 31%. All treatments with the flamer resulted in very active fire behavior, leaving a 30-100 ft hot fire behind the tractor. This resulted in beetle kill that appears quite good, 5-17% survival for all treatments, compared to 85% survival in the check block. The fire behavior probably equalized all treatments, since they all ignited, making any differention between treatments difficult. Application on 21, April, required active fire suppression and did not appear to differ greatly from a prescribed burn.

The field trial conducted on 3 May was done on the same day as the operational trial. Fuel moistrure was 17%. Fire behavior was much less intense than the previous trial because green-up had begun. Beetle survival was very erratic in the treatments. The crawl and slow speed treatments appeared to have provided good control, 6 and 12% survival, respectively (Table 1). However, the faster treatments actually had better survival than the check treatment.

Table 1. Results from plot trials conducted at the Oconto River Seed Orchard, Nicolet National forest, Wisconsin, in 1994.

DATE MONTH/DAY	% FUEL[1] MOISTURE	TREATMENT[2]	BURNER[3] ANGLE	% BEETLE SURVIVAL
4/6	195	Check	90	59
4/6	195	Slow	90	67
4/6	195	Medium	90	54
4/6	195	Fast	90	65
4/13	151	Check	90	67
4/13	151	Slow	90	45
4/13	151	Medium	90	18
4/13	151	Fast	90	40
4/21	13	Check	90	85
4/21	13	Crawl	90	11
4/21	13	Slow	90	7
4/21	13	Medium	90	17
4/21	13	Fast	90	5
5/3	17	Check	90	47
5/3	17	Crawl	90	6
5/3	17	Slow	90	12
5/3	17	Medium	90	50
5/3	17	Fast	90	68
5/5		Check	30	82
5/5		Crawl	30	22
5/5		Slow	30	62
5/5		Medium	30	55
5/5		Fast	30	66
5/12	24	Check	30	69
5/12	24	Crawl	30	37
5/12	24	Slow	30	31
5/12	24	Medium	30	39
5/12	24	Fast	30	41

[1]Moisture content as a percent of oven dried weight of cones killed in 1993 by cone beetles.

[2]Treatments consisted of an untreated check block, and blocks treated with the propane flamer unit pulled at 3 or 4 different speeds (crawl = 1st gear, slow = 2nd gear, medium = 3rd gear, fast = 4th gear).

[3]Angle that individual burner units were oriented in comparison to the ground (90° = burner directly towards the ground).

The trial conducted on 5 May was the first with the propane flamers modified to a 30° angle versus the 90° angle (straight up and down) used earlier. Fuel moisture was --. Cone beetle survival was again erratic over all treatments (Table 1), though survival over all treatments was less than the check block. The slowest treatment, crawl speed, did have only 22% survival.

The trial conducted on 12 May had a fuel moisture of 24%. All treatments showed a reduction in beetle survival (Table 1), though no treatment reduced survival below 30%. Fire behavior was noted as hot but easily suppressed. Green-up was well under way in the orchard.

These initial trials with the specific flamer we used brought out several points, including:

> Fine fuels and cones must be dry to obtain adequate control. This reduces the window available for treating orchards and increases the fire hazard. A specific minimum fuel moisture necessary for control has not been documented.
>
> Fire behavior becomes much more manageable once green-up begins.
>
> The lethal temperature for cone beetle control should be reexamined. The flamer appeared to apply intense heat and in addition caused ignition of most fuels, yet control in most cases was not extremely good.
>
> A number of adjustments on increasing pressures and burner angle should be done to attempt to improve killing efficiency of the flamer.

Operational burn: A perimeter burn was started at about 0830 on May 3. the intent was to burn a perimeter around the orchard to act as a fireline and then burn the middle of the orchard. Temperature was 50°F and 75% RH. After burning a short distance the burn terminated when it was noticed that several gas hoses had heat-checked. The flamer was then modified to eliminate the problem of excessive heat and flame rolling back toward the tractor and the hoses and wiring in that area. This was done by changing the angle of the burners from directly down (90°) to ca. 30° from horizontal. This aimed the heat and flame away from the tractor. In addition, a heat shield was constructed to further protect hoses and wiring for the electronic ignition.

At about 1530 the burn was restarted. Temperature was 70°F, humidity was ca. 40%. After the perimeter was burned, alternate rows were burned on a diagonal in a SE-NW direction. Fire ignition was terminated at 1930 and a fire watch was maintained until 2200. Burning was continued at 0900 on May 4. Conditions were much the same as the previous day. Burning was completed in all rows in a SE-NW direction. Then rows in a SW-NE direction were treated. This resulted in a very complete burn, at least 95

% of the orchard was blackened. Much of the orchard was exposed twice to the heat produced by the burner. The project was completed at 1600, though a fire watch was continued until 1900.

Moisture content of cones was 18%. Moisture content of needles (fine fuels) was 11%. Fuel loading was estimated at 5 tons/acre.

Approximately 245 gallons of propane was required to complete the 10 acre orchard. Propane costs approximately 60 cents/gallon. Therefore, cost of the propane was approximately 147 dollars. The orchard took ca. 11 hours to complete. On site during the burn was a group of approximately 7 people who were there to maintain the fire lines.

Beetle survival in cones prior to the treatment was 83 percent. Post-burn samples found 11 living beetles and 48 dead beetles (19 % survival).

References

DeBarr, G.L., L.R. Barber and A.H. Maxwell. 1982. Use of carbofuran for control of eastern white pine cone and seed insects. For. Ecol. and Manage. 4:1-18.

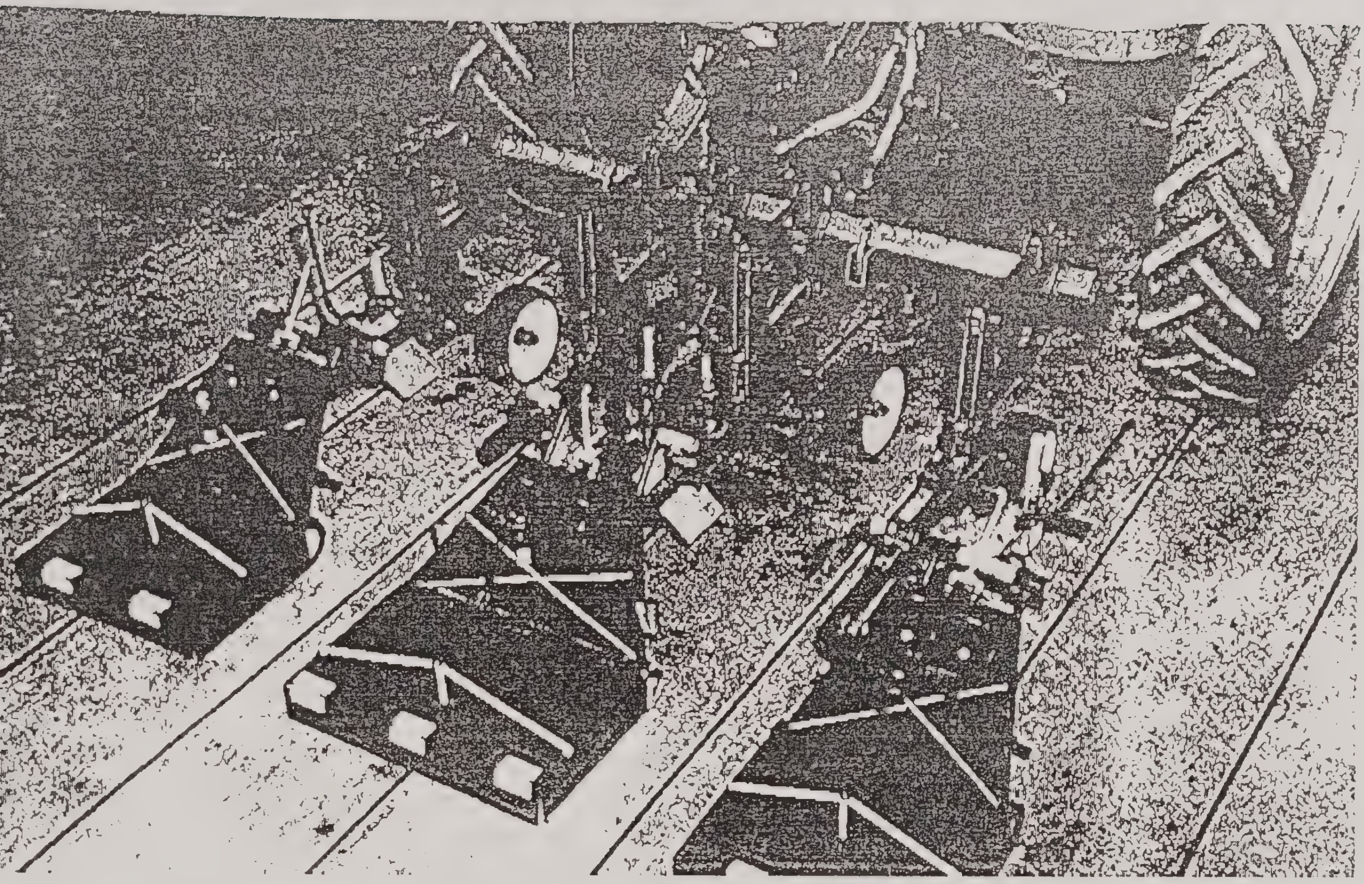
Miller, W.E. 1978. Use of prescribed burning in seed production areas to control red pine cone beetle. Environ. Entomol. 7:698-702.

Miller, W.E. 1979. Fire as an insect management tool. Entomol. Soc. Am. Bull. 25:137-140.

Moyer, D.D. 1992. Fabrication and operation of a propane flamer for Colorado potato beetle control. Cornell Cooperative Extension, 7 pp.

Wade, D.D., G.L. DeBarr, L.R. Barber and E. Manchester. 1989. Prescribed fire - a cost effective control for white pine cone beetle. pp. 117-121. In Proceedings of the 10th conference on fire and forest meteorology, eds. D.C. Maciver, H. Auld and R. Whitewood, Ottawa, Canada, 471 pp.

Prototype hooded burners



Steam Generator Information

SASKATOON BOILER MFG. CO. LTD.

2011 QUEBEC AVENUE, SASKATOON, SASK., CANADA S7K 1W5

Telephone (306) 652-7022 Fax (306) 652-7870

July 19, 1994

U.S. Forest Services
M.T.R.C.
Fort Missoula, Montana
Missoula, Montana 59801
U.S.A.

ATTENTION: Dick Karsky

Dear Sir:

We are pleased to submit the following **Proposal No. 8171** for equipment to be supplied as a SASKATOON Portable Steam Boiler in accordance with your request. Specifications are as follows:

BOILER:
One (1) SASKATOON Boiler Scotch Marine dry back two pass type, **Model 36-HP-15** rated at 30 horsepower. Steam output of 1035 pounds of steam per hour from and at 212°F. Boiler design registered in accordance with C.S.A. and A.S.M.E. Codes; design pressure 150 psi. Boiler is insulated with 2" fiberglass insulation and aluminum jacket.

BOILER TRIM:
A complete set of standard boiler fittings are supplied with this unit, which includes:

One	2-1/2" x 200# Steam Gauge with graduated reading from 0 to 200 psi.
One	Safety Valve set to relieve at 100 psi.
One	Set 1/2" Gauge Glass Mountings complete with sight glass and guards.
Three	1/2" brass Tri-Cocks.
One	1" Lubricated Quick Opening Blow-off Valve with handle, and one slow opening valve.
One	1" Gate Valve for blowdown on low water control.
One	1" Steam Supply Valve.
One	2" Flue Brush with handle for cleaning tubes.
One	50' Length 3/4" Steam Hose.
Two	Operating Manuals.

FEEDWATER SUPPLY:
Automatic feedwater make-up to the boiler, this includes:

One	Combination Low Water Cut-off and Pump Control.
One	Boiler Feed Pump c/w motor.

Low water cut-off and pump control is wired to the oil burner and pump motor to automatically maintain the water in the boiler at a safe operating level.

WATER STORAGE:
Approx. 150 U.S. gallon water storage tank of all welded steel construction is mounted below the boiler. Pump is piped to the water storage tank complete with all necessary shut-off valves. Water storage tank shall be insulated to prevent freezing in cold weather. Tank is insulated with 1" fiberglass insulation and aluminum jacket.

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

[illegible]

TO: U.S. Forest Services
Date: July 19, 1994
Proposal #: 8171

OIL BURNER:
One Gun Type Oil Burner with a rated capacity to burn 8 gallons of #1 or #2 oil per hour. Oil burner is piped to the fuel oil supply tank with a self-priming two pipe system and electrically wired to the power supply, with all necessary safety controls for automatic firing according to Underwriters Specifications. Controls supplied include:

One Flame Safeguard Relay and Photocell Flame Detector.
Two Pressure Switches with a range from 10 to 150 pounds.
One Oil Filter.

OIL STORAGE:
Approx. 55 U.S. gallon oil supply tank of all welded steel construction is mounted below the boiler.

RUNNING GEAR:
Complete portable unit is mounted on a two wheel type running gear. Complete with 700 x 15 truck type tires, adjustable drawbar for ease of levelling and towing of unit. Unit is complete with fenders and springs.

POWER SUPPLY:
One 5000 watt Generating Plant is supplied and mounted on unit to furnish 120 volt power to operate oil burner, pump motor, and all electrical controls. Generating plant is wired to a main switch panel on the boiler and is equipped with manual start after which unit is completely automatic.

DELIVERY:
Delivery of the foregoing described unit would be made within approx. 45 days from date of receipt of order at Saskatoon, Saskatchewan.

SHIPPING WEIGHT:
Approx. 6,000 pounds.

We wish to thank you for the opportunity of submitting this information and trust that you will find it acceptable.

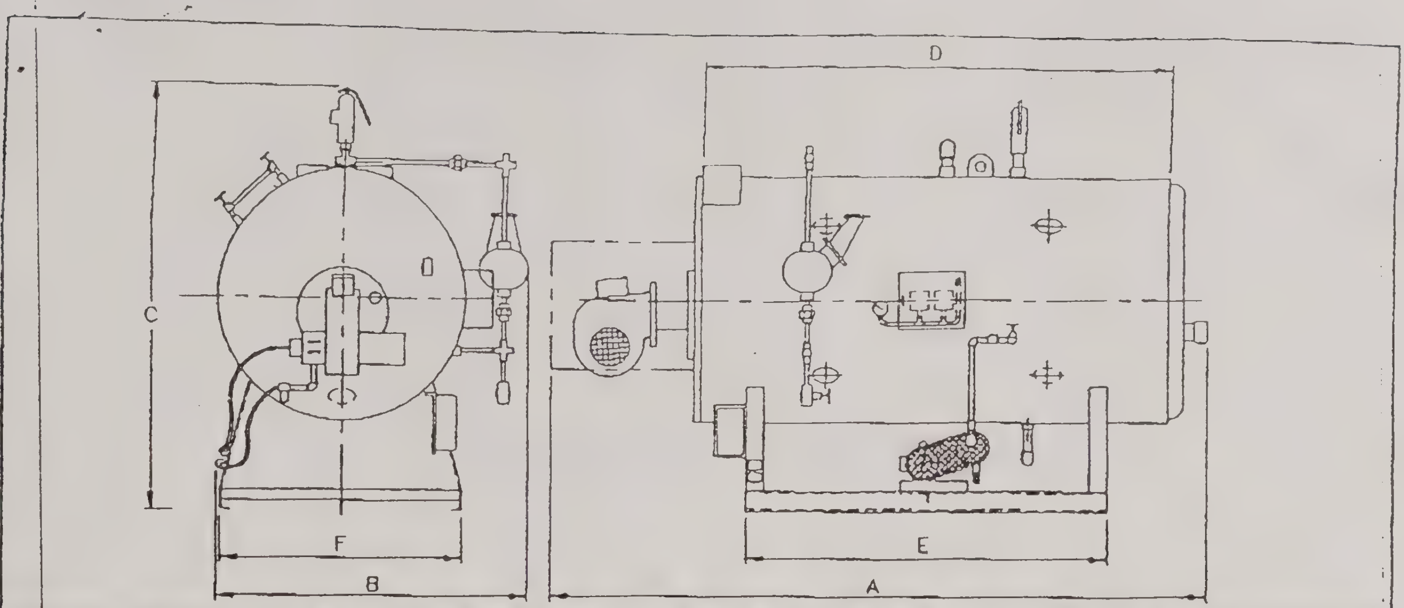
Yours very truly,

SASKATOON BOILER MFG. CO. LTD.

Ernie Belke

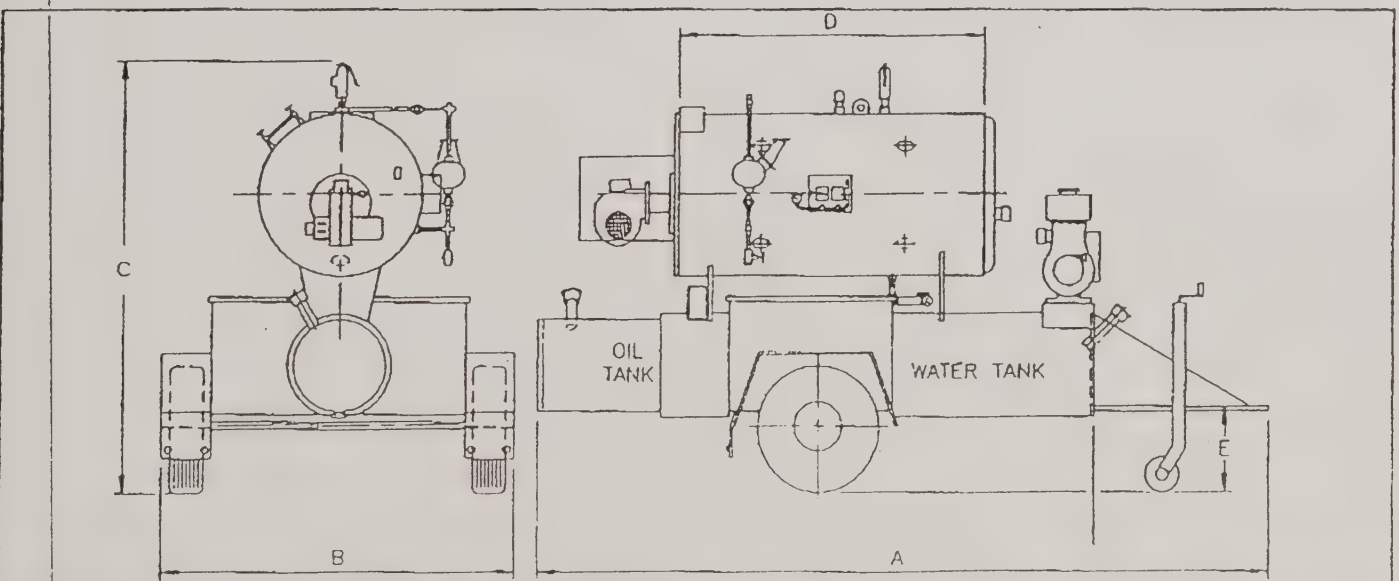
Ernie Belke,
Representative

EB/jk



SKID MOUNTED

RATING		MODEL	HEATING SURFACE		STEAM OUTPUT F&A 212°F(100°C)		A		B		C		D		E		F		SHIPPING WT	
HP	KW	NUMBER	sq ft	sq m	lb/hr	kg/hr	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	in.	mm.	LB.	KG.
10	98	24-HPS-5	50	4.6	345	156	80	2030	38	965	58	1475	58	1475	42	1070	24	610	1450	660
15	147	30-HPS-7	75	7.0	518	235	84	2135	44	1120	63	1600	60	1525	41	1040	30	760	2200	1000
20	196	30-HPS-10	100	9.3	690	313	103	2615	44	1120	63	1600	72	1830	53	1345	30	760	2400	1090
25	245	30-HPS-12	120	11.1	862	391	115	2920	44	1120	63	1600	84	2135	64	1625	30	760	2600	1180
30	294	36-HPS-15	150	13.9	1035	469	110	2795	50	1270	64	1625	76	1930	60	1525	36	915	3200	1450

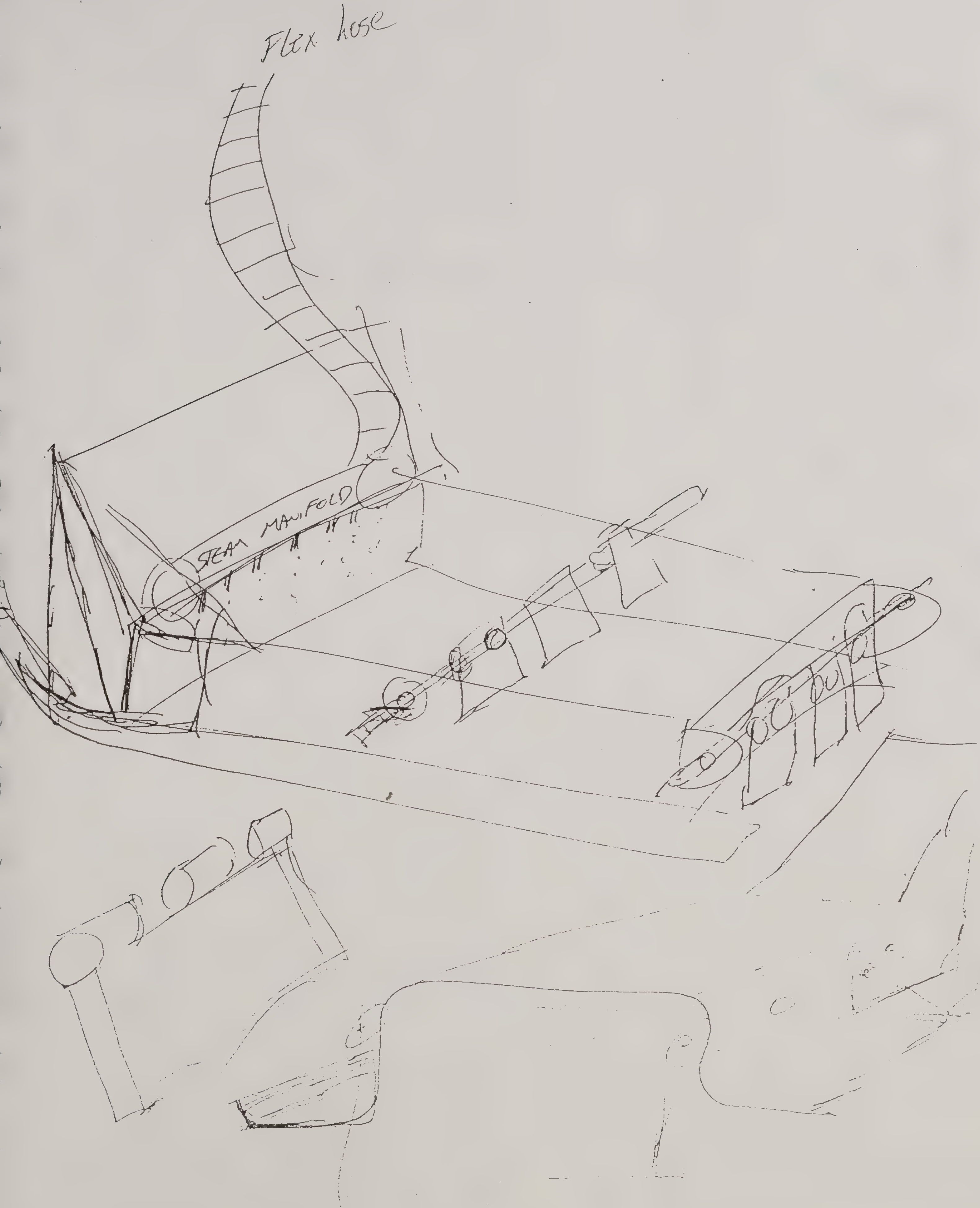


WHEEL MOUNTED

RATING		MODEL	HEATING SURFACE		STEAM OUTPUT F&A 212°F(100°C)		A		B		C		D		E		OIL TANK		WATER TANK		SHIPPING WT	
HP	KW	NUMBER	sq ft	sq m	lb/hr	lb/kg	in.	mm.	in.	mm.	in.	mm.	in.	mm	in.	mm.	US Gal	L.	US Gal	L.	LB.	KG.
10	98	24-HP-5	50	7.6	345	156	152	3860	80	2030	87	2210	58	1475	24	610	36	135	100	380	3050	1380
15	147	30-HP-7	75	7.0	518	235	152	3860	80	2030	93	2360	60	1525	24	610	36	135	100	380	3750	1700
20	196	30-HP-10	100	9.3	690	313	182	4625	80	2030	93	2360	72	1830	24	610	46	175	128	485	4100	1860
25	245	30-HP-12	120	11.1	862	391	182	4625	80	2030	93	2360	84	2135	24	610	46	175	128	485	4300	1950
*30	294	36-HP-15	150	13.9	1035	469	171	4345	78	1980	86	2185	76	1930	20	510	68	255	204	770	6000	2720

* Tandem Axel Unit

Steamer Box - Crude Sketch


Flex hose
STEAM MANIFOLD

Manufacturer Brochures

0/2/14

WEISS/McNAIR, INCORPORATED 531 Country Drive • Chico, California, 95926 • (916) 891-6214

FAX # (916) 891-5905

COMPANY NAME: Keith Windell

ATTENTION:

SENDER: Larry Demmer

PAGES TO FOLLOW: 11

PLEASE REPLY BY:

COMMENTS: Enclose please find information on our Pine Cone harvester (very poor quality pictures), our sweeper and our model 836H harvester. This harvester is in current production and doesn't have any augers inside. Cost is 21750^{00}. The discontinued harvester that I am going to get you some pictures of is very similar to the 836H

WEISS/McNAIR

836H

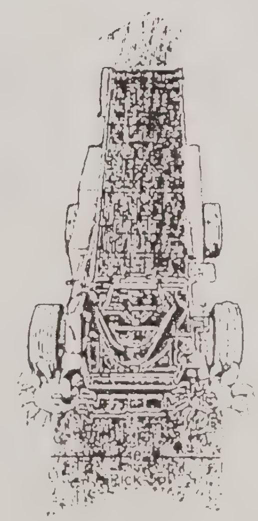
with a built-in hydraulic system

P.T.O. Pick-Up HARVESTER

Straight-thru 36" Elevator for faster WALNUT and ALMOND harvesting!

- MINIMUM PARTS MEAN LESS MAINTENANCE & PART REPLACEMENTS
- 4-STAGE "AIR-VAC" CLEANING SYSTEM FOR COMPLETE TRASH SEPARATION
- RUGGED DEPENDABILITY WITH EXTRA RE-INFORCEMENTS IN ALL WEAR AREAS
- BUILT-IN HYDRAULIC SYSTEM PERMITS VARIABLE SPEED CONTROL OF THE ELEVATOR CHAIN AND FRONT SWEEPERS

The new WEISS/McNAIR 836H Harvester reflects the new standard of design, strength and simplicity. It has minimum of parts yet has maximum harvesting efficiency. The time proven 4-stage cleaning system separates trash rapidly, completely without destroying the nuts. This economical harvester is a true straight thru 36" with unrestricted flow that permits faster ground speed. All moving parts are safely covered with easy to open, heavy gauge guards that are held in place with convenient rubber latches.



The Sign of Quality

Qualified WEISS/McNAIR sales representatives welcome your request for a demonstration. Write or call us direct.

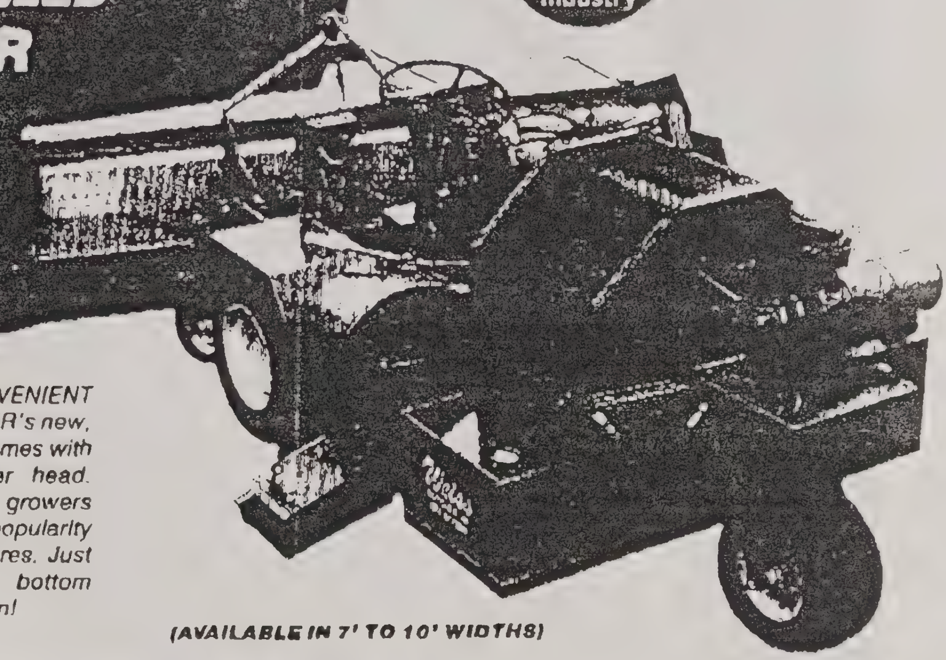
WEISS/McNAIR, INC. [illegible] Chico, CA 95926 (916) [illegible]

WEISS/McNAIR
(Diesel Powered)
HSD40
SELF-PROPELLED SWEEPER

(HS 35 Model with 35 H.P. Wisconsin Gasoline Engine also available)

YEAR-ROUND WORK HORSE FOR BIGGER YEAR-END PROFIT!

BEST VALUE In the Industry



(AVAILABLE IN 7' TO 10' WIDTHS)

FUNCTIONAL, VERSATILE AND CONVENIENT are the words that describe WEISS/McNAIR's new, rugged HSD40 self-propelled sweeper. It comes with either auger reel or tine bar sweeper head. Incorporating suggestions from many growers throughout the country, the HSD40's popularity reflect the merits of its many quality features. Just check for yourself, it's there on the bottom line. . . lower investment with a high return!

PROVEN MULTI-PURPOSE SWEEPER . . . DESIGNED TO EARN ITS KEEP!

■ **SUPER BLOWER:**
The HSD40's powerful blower is not mounted on the engine shaft. . . therefore runs only when it is needed.

■ **EXTRA RESERVE POWER:**
The powerful 40 H.P. DEUTZ diesel engine has maximum reserve power even with the blower engaged.

■ **BUILT-IN ENGINE PROTECTION:**
The engine is well protected with heavy-duty screen to keep out leaves and nuts.

■ **POWERED MANEUVERABILITY:**
Power steering and full hydrostatic drive provide instant control response for ease of operation. Tricycle (rear steering) design allows for short turns to avoid running over nuts.

■ **WELL DESIGNED:**
Up front operator position provides excellent vision. The low profile design permits easy maneuverability to sweep under low-hanging limbs.

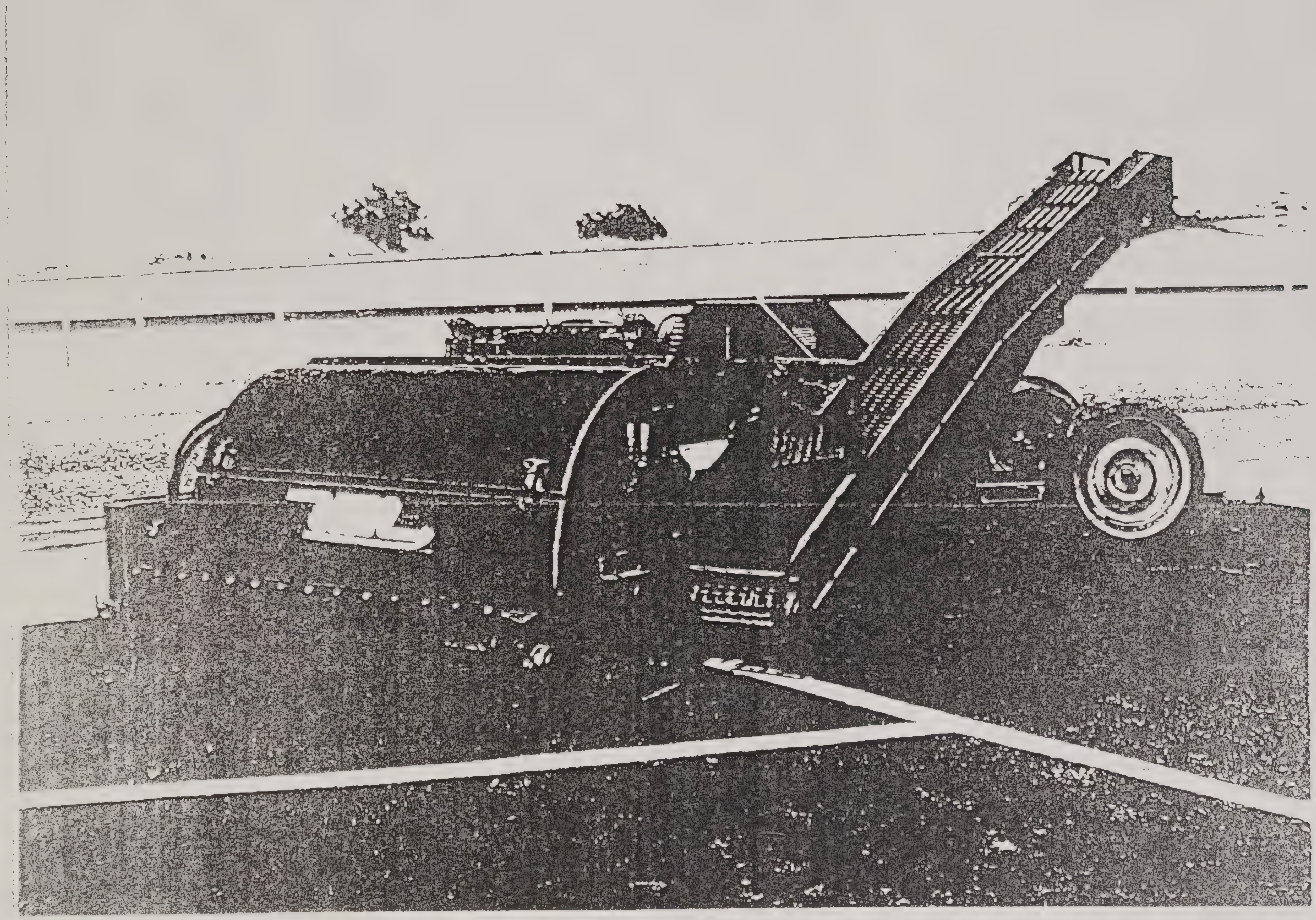
■ **VERSATILE:**
The sweeper head can be quickly disconnected and the power unit can be used for spraying, mowing, trenching, wood splitting, etc. The hydraulic system provides 8 G.P.M. at pressures up to 2,000 P.S.I.

A Leader In The Nut Harvesting Industry Since 1966

WM

WEISS/McNAIR, INC., 531 Country Drive, Chico, CA 95928 (916) 891-6214

Self propelled Pine Cone Harvester



THE WEISS-MCNAIR CONE HARVESTER

G.A. Lowerts and M.H. Zoerb, Jr.[1/]

912-826-5556

Abstract. -- The Weiss-McNair cone harvester is a gasoline powered machine that scoops up slash (*Pinus elliottii* Englem. var. *elliottii*) and loblolly (*P. taeda* L.) pine cones from the orchard floor using two paddle wheels. The cones are then moved via two conveyor belts to a 20 bushel crate on a trailer at the rear of the machine. An air blower removes pinestraw and small sticks that were picked up with the pine cones. The cone harvester has substantially reduced total cone harvest cost.

Union Camp Corporation has been actively involved with a tree improvement program for loblolly and slash pines for over three decades. The establishment and management of seed orchards has been a basic component of the tree improvement program. The harvest of pine cones from the orchards is the most expensive aspect of seed orchard management. ~~The benefits of seed orchard management activities (e.g. fertilization, insecticides, mowing, etc.) as well as tree improvement clonal information~~ will be substantially ~~reduced if the~~ cone ~~harvest~~ is not conducted ~~in a timely and efficient manor.~~

TO ACHIEVE MAXIMUM BENEFIT FROM ORCHARD MANAGEMENT PRACTICES THE CONE HARVEST MUST BE CONDUCTED IN A TIMELY & EFFICIENT MANNER.

The harvest of pine cones from Company orchards has risen from three bushels of slash pine first generation cones collected in 1962 to over 5,500 bushels of loblolly and slash pine first, 1.5, and second generation cones collected in 1986. In twenty-four years, the Company has harvested over 100,000 bushels of cones representing nearly 120,000 pounds of improved seed. At present, Union Camp Corporation has over 440 acres of pine seed orchard of which 335 acres are producing pine cones. Because of the high cost of harvesting pine cones and the increasing potential for large cone crops due to enhanced management practices and increasing orchard tree size, the Company has examined and tested several cone harvesting systems.

PINE CONE HARVESTING PROCEDURE

A TREE SHAKER IS USED TO DISLODGE THE SLASH PINE CONES

~~The pine cone harvest begins when a tree shaker shakes loose ripe slash pine cones in mid-September.~~ ~~All slash pine orchard trees are shaken to dislodge the pine cones~~. Loblolly pine cones are picked by hand with two-man crews in aerial lift trucks. The clones within the loblolly and slash pine seed

---

1/ Seed Orchard Manager and Tree Improvement Project Leader, respectively, Woodlands Research Department, Union Camp Corporation, Rincon, Georgia 31326 USA.

The increased efficiency and speed of the cone pickup off the orchard floor are among the advantages of using the mechanical cone harvester. In 1984, a record cone production year, the cone harvester picked up 20 bushels of loblolly pine cones in twenty-five minutes compared to the 40 bushels picked up by a three man crew in seven hours. The greatest benefit is the reduction in labor costs since fewer temporary employees are needed to pick the cones from the orchard floor.

Detailed information on the cone harvester mechanical specifications and current cost of the machine are available from:

The Weiss-McNair cone harvester is manufactured by:

Weiss-McNair Incorporated
531 Country Drive
Chico, CA 95926
(916) 891-6214

Appendix A. Weiss-McNair Cone Harvester Specifications.

GENERAL

Engine - - Wisconsin Model VH4D; 30 h.p. @ 2800 RPM

Transmission - - Eaton Hydrostatic

Hydraulic Pump - - Sperry Rand

Power Drive Wheels - - Two 26 X 12.00 X 12 Knob Grip Tires

Steering Rear Wheel - - One 18 X 9.50 X 8 Turf-Saver

Hydraulic Oil - - 12 gallon capacity

Gasoline - - 12 gallon capacity

Fuel Consumption - - 2 gallons per hour

FLOATING PICKUP HEAD

Size - - Five Feet Wide; Three Feet High; Three Feet Long

Paddle Wheels - - One 30 in. Diameter with 5 in. Rubber Paddles
- - One 10 in. Diameter with 5 in. Rubber Paddles

Conveyer Belt - - One 5 ft. X 12 in.; rubber

Tires - - Two 13 X 6.50 X 6

CONVEYER TO CONE CRATE

Conveyer Belt - - one 12 ft. X 10 in.; chain link

Blower Fan - - 24 in. X 9 in. Paddle Fan

Air Duct - - 12 in. Diameter To 5 in. X 10 in. Air Shoot

Metal Cone Slide - - 16 in. X 30 in. Metal Slide @ 45^{o} Angle To Crate

CONE CRATE TRAILER

Capacity - - One 20 Bushel Crate

Trailer - - Metal Frame

Tires - - Two 4.80 X 8

RAMACHER

5023 N. Flood Road
Post Office Box 506
Linden, California 95236
Fax: 209•887•3248
209•887•3815

August 03, 1994

Keith Windell
US Forest Service - MTDC
Fort Missoula Bldg. #1
Missoula, Montana 59801

Subject: Pine Cone Harvest

As discussed during our telephone conversation of August 2nd, I have enclosed literature and prices on Ramacher Mfg. Inc. harvesters and sweepers.

The rental rate for the 6470 Sweeper is $8,700 per month and the 9500 Harvester is $7,000 per month. Rental prices are F.O.B. Linden, CA. The US Forest Service would be responsible for any damage to the equipment and excessive wear or damage to wear parts. All soil, branches, pine cone resin-pitch, would have to be removed from the equipment prior to returning to Ramacher.

Request for optional equipment, ie. limb guards could increase the rental prices. Rental purchase programs are also available.

The time of year you mentioned - April - is the best for off season rentals, harvest season for us starts in July.

Please review our literature and give me a call if you have questions.

Joe

Joe Vallery
Sales Manager
RAMACHER MFG. INC.

JV/cr

Enclosure

RAMACHER
5023 N. Flood Road
Post Office Box 506
Linden, California 95236
Fax: 209•887•3248
209•887•3815

JANUARY 1, 1994

PRICE LIST - HARVESTERS

PTO HARVESTERS	DOLLARS
DCS - PTO	27,500
9500 Pecans - Hyd. Hitch	22,600
9510 Walnuts - Hyd. Hitch	22,450
9520 Almonds - Hyd. Hitch	21,800
9530 Filbert - Hyd. Hitch	21,800
9540 Figs - Hyd. Hitch	21,800

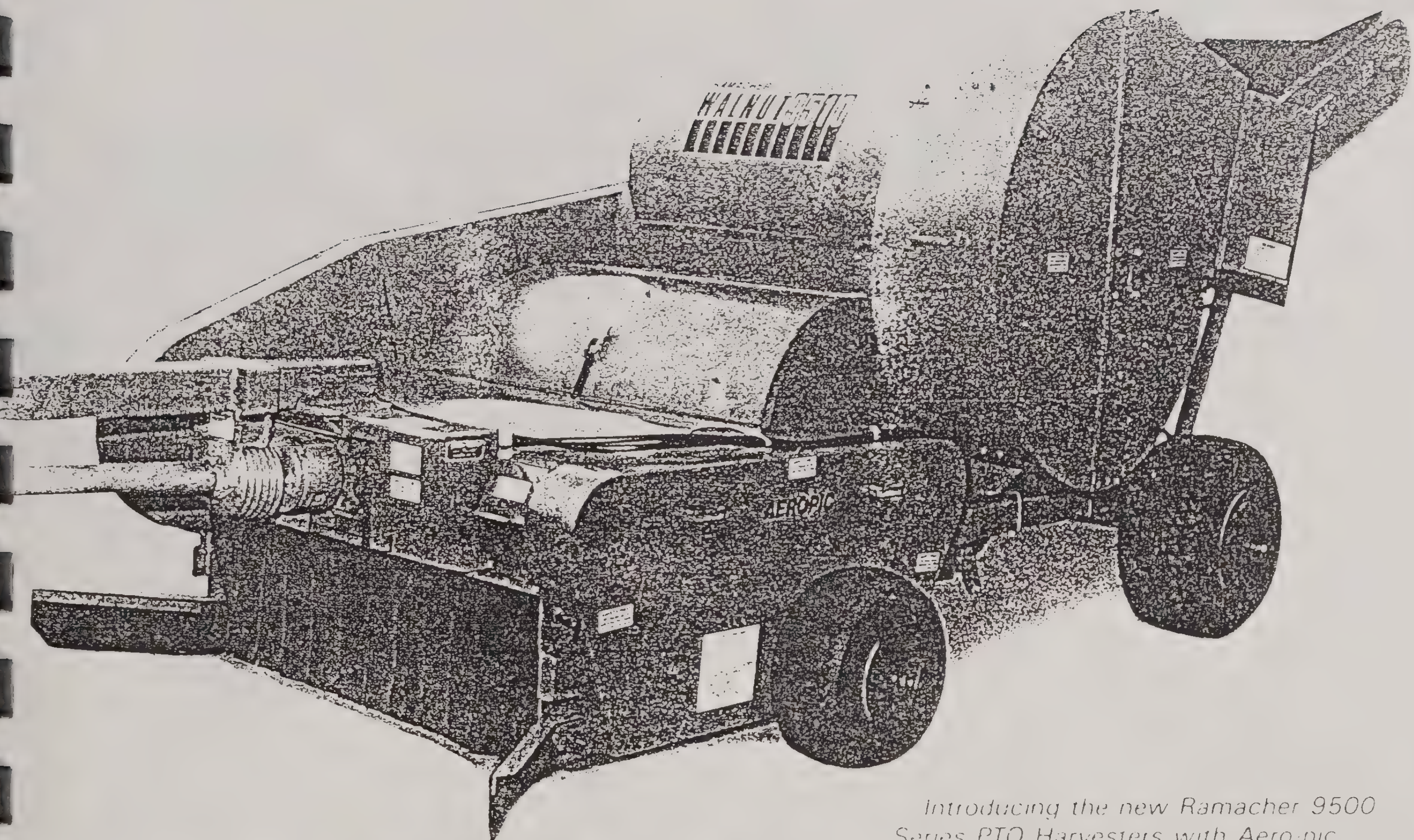
SELF PROPELLED HARVESTERS - JOHN DEERE 110 HP

DCS - SP	62,000
9600 Pecans	58,800
9610 Walnuts	58,200
9620 Almonds	56,600
9630 Filberts	56,600
9640 Figs	56,600

OPTIONS

Dual Wheel Cleaners (9600)	5,230
Flare Cleaners (9500) Closed Center Hyd.	2,530
Flare Cleaners (9500) Open Center Hyd.	2,760
Extra Chain (9500) - WALNUT TUBE 78500-01	2,260
ALMOND 78369-02	1,190
PECAN/FILBERT 78369-03	1,380
PECAN/FILBERT ROD 78513-01	2,580
Extra Chain (9600) - WALNUT TUBE 78502-01	2,520
ALMOND 78499-03	2,210
PECAN/FILBERT 78499-06	1,410
PECAN/FILBERT ROD 78513-01	2,580
ESPARTO HYD. TRAILER CONTROLS	1,140
AUGER CART MOTOR & CONTROL W/HOSES (9600)	880
AUGER CART MOTOR W/HOSES (9500)	620
NIGHT LIGHTS (All)	550
BANKOUT CONTROLS (9600)	1,270
4-WHEEL DRIVE (9600)	7,950
MURPHY SWITCH (9600) OIL & WATER	420
TOTE BOX FUNNEL (9500-9600)	*
AIR CAB (9600)	*

*PRICE AVAILABLE UPON REQUEST
ALL PRICES F.O.B. LINDEN, CALIF. PRICES AND SPECIFICATIONS SUBJECT



The new RAMACHER

PTO HARVESTERS

Pecan 9500
Walnut 9510
Almond 9520
Filbert 9530
Fig 9540

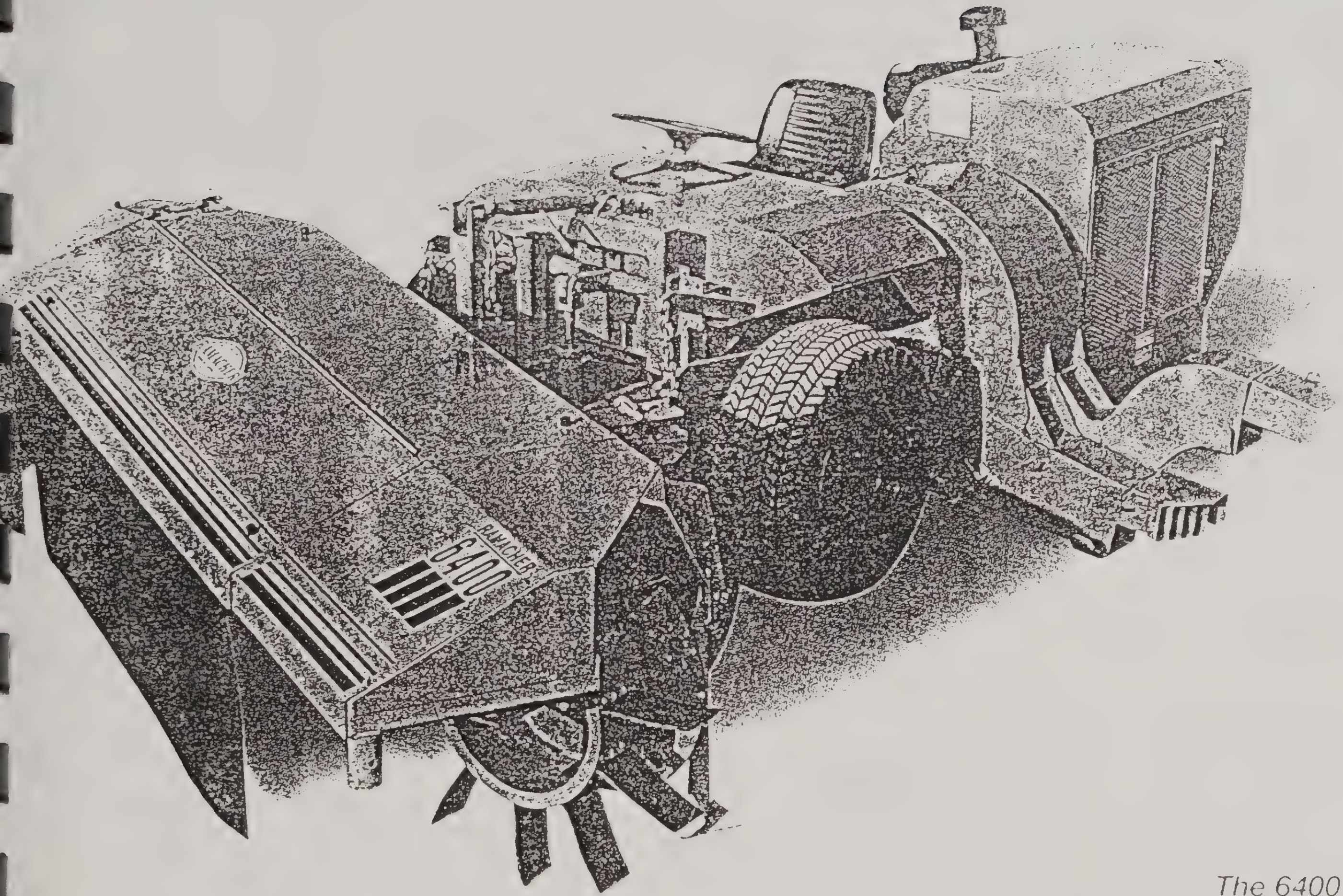
Introducing the new Ramacher 9500 Series PTO Harvesters with Aero-pic. A system so advanced its efficiency and dependability are unsurpassed.

The Aero-pic System incorporates Ramacher's proven components; a dual reel soft pick-up, a powerful suction fan, and an aerodynamically designed separation chamber.

The dual pick up reels have been re-designed to pick up large, wet and dirty windrows at high speed without damage to crops. The windrow is continuously showered into the separation chamber where its aerodynamic design actually sculptures the air flow to suspend the [illegible] and remove [illegible] the trash [illegible] leaves. The nuts then gently fall [illegible] the conveyor belt system where they are quickly whisked to the trailer.

In [illegible] plugging, the 9500 Series [illegible] harvest[illegible] [illegible] separation chamber [illegible] components.

[illegible] the new 9500 Series [illegible] the Aero-pic System [illegible]



The New RAMACHER

SWEEPER

The 6400 Sweeper is powered by the John Deere 4239 Diesel Engine. This engine is built to last and can produce 70 HP when operated at 2200 RPM. The 6400 has increased blower power to provide the largest blowing capacity in the industry.

The Ramacher 6400 Sweeper has an advanced hydraulic system and hydrostatic drive to reduce down time. The pump drive is newly designed to eliminate belt maintenance and periodic slippage common to belt drives.

This new model offers maximum operator convenience and safety. The 6400 blower has a new foot control design that leaves the operator's hands free for other controls. The specially designed blower output system allows the operator to control the blower output with the engine's RPM, resulting in longer engine life, less fuel consumption and more quiet operation.

Check out the Ramacher 6400 Sweeper. It offers quality and performance at an affordable price. Ask your Ramacher Salesman [illegible]

Industry since 1936

1936-1986

FLORY INDUSTRIES

MARLIN FLORY

3
IA 95368

PHONE (209) 545-1167 / FAX 545-4924
4737 TOOMES ROAD

P. O. Box 908
a, Calif. 95368
7 Toomes Rd.

Bus. (209) 545-1167
FAX (209) 545-4924

August 2, 1994

Mr. Keith Windell
United States Forest Service
MTDC Fort Missoula Bldg #1
Missoula, MT 59801

Dear Mr. Windell:

Enclosed are brochures showing our current Models of Sweepers and Harvesters with prices.

Since you do not require cleaning of the pine cones, we have a P.T.O. Harvester that we can leave the cleaning fans off and sell to you for a price of $5,800.00. A used sweeper would sell for a price of $11,000.00. These prices are F.O.B. factory, Salida, California. We would need three weeks lead time to get these units ready for shipping.

If the equipment would not work for your application, we would refund the amount paid upon receiving the equipment, freight prepaid.

Thank you for checking with me and I look forward to hearing from you.

Best regards,

FLORY INDUSTRIES, INC.

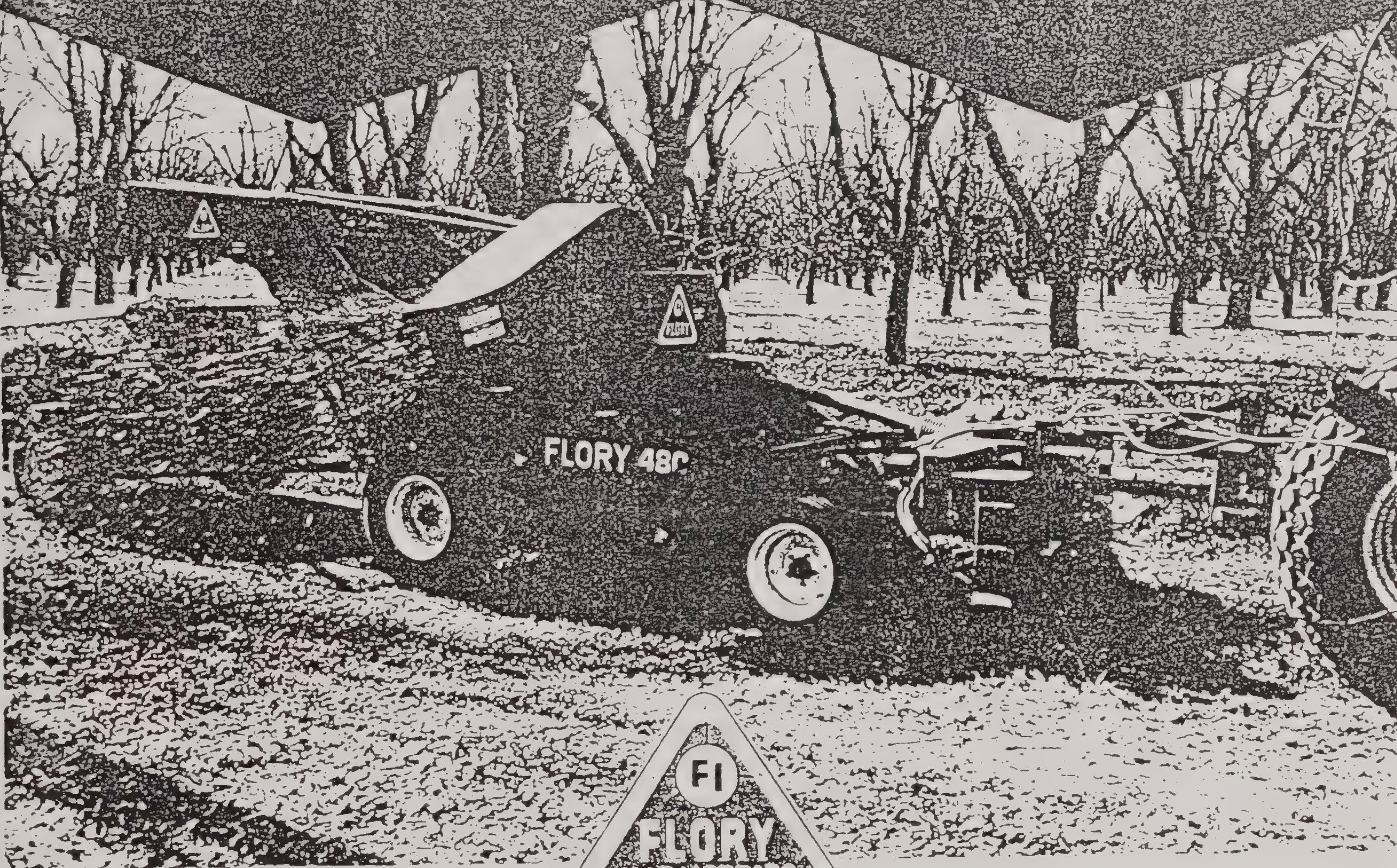
Marlin Flory

MF/jc

Enclosures

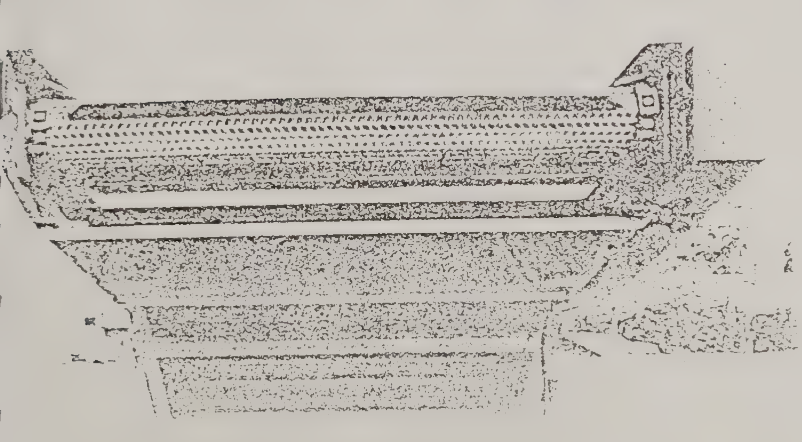
NEW

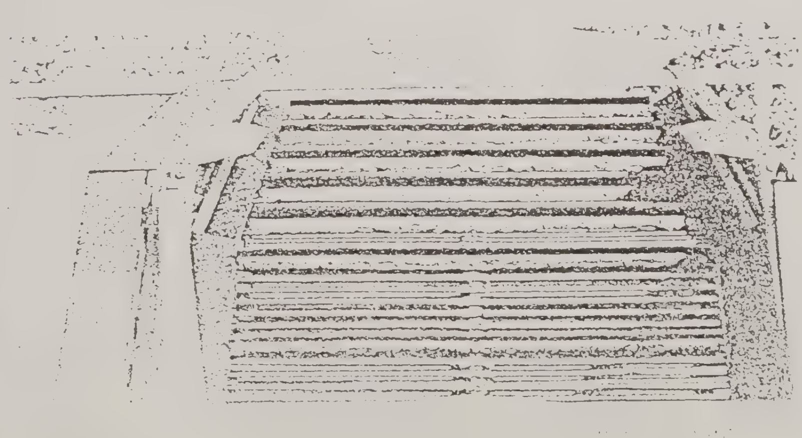
The NEW FLORY 480 P.T.O. and 4800 SELF-PROPELLED HARVESTERS with the NEW Tri-Sep Cleaning Systems



FI
FLORY
INDUSTRIES

More Cleaning. Less Wear.





THE FLORY 50 SERIES SWEEPER
...sweeping the country.

FLORY

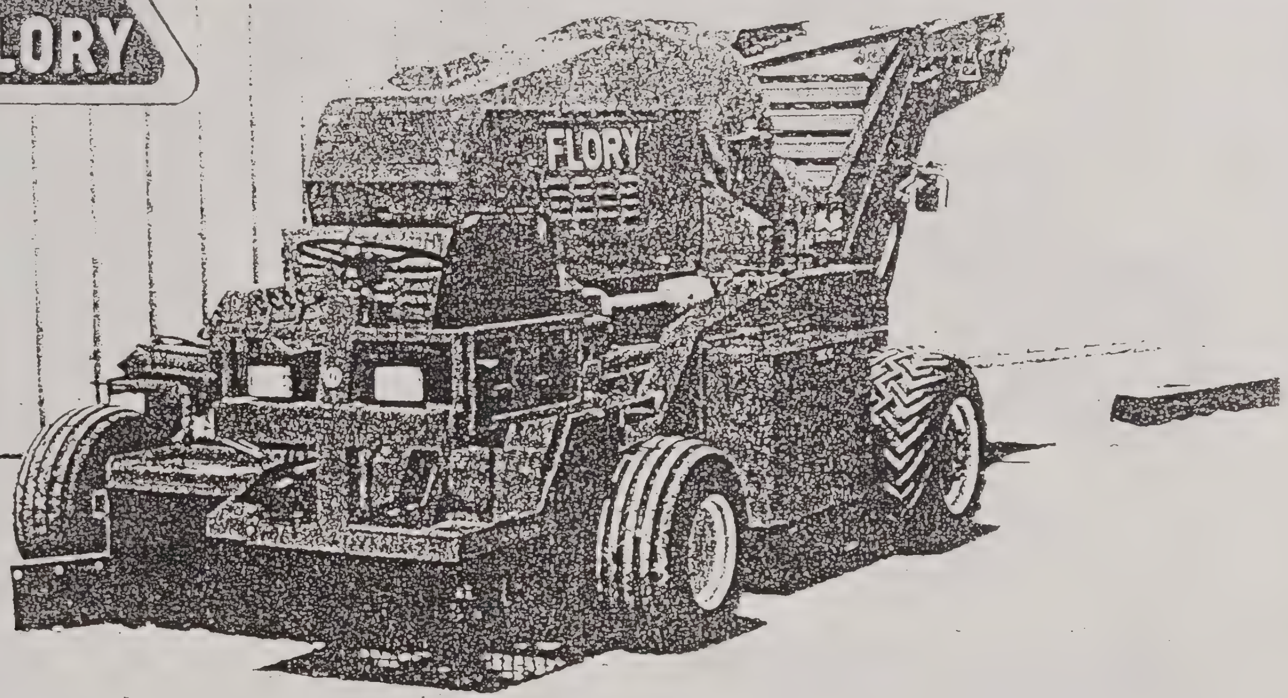
In over 25 years of building sweepers... the Flory 50 Series Sweeper has come to the ultimate in crop recovery with the maximum in sweeping performance! This heavy duty sweeper provides more blowing power for those rugged and hard-to-get-at places. It not only sweeps with ease in heavy leaf and trash conditions, but the variable reel drive allows you to increase the reel speed for heavier going and faster sweeping when [illegible] on the ground! [illegible] Flory 50 Series Sweeper with high flotation tires... allows you to sweep on even or uneven terrain under adverse soil conditions. Flory's 5 bar reel reduces tooth speed for cleaner sweeping as well as prolonging teeth life resulting in effective sweeping on all types of nuts. These Flory fuel efficient, and low maintenance self propelled sweepers have lowered harvesting costs, and have raised profits for growers throughout the World!

FLORY SWEEPING THE COUNTRY.

7400 SERIES

SELF - PROPELLED HARVESTER

FLORY



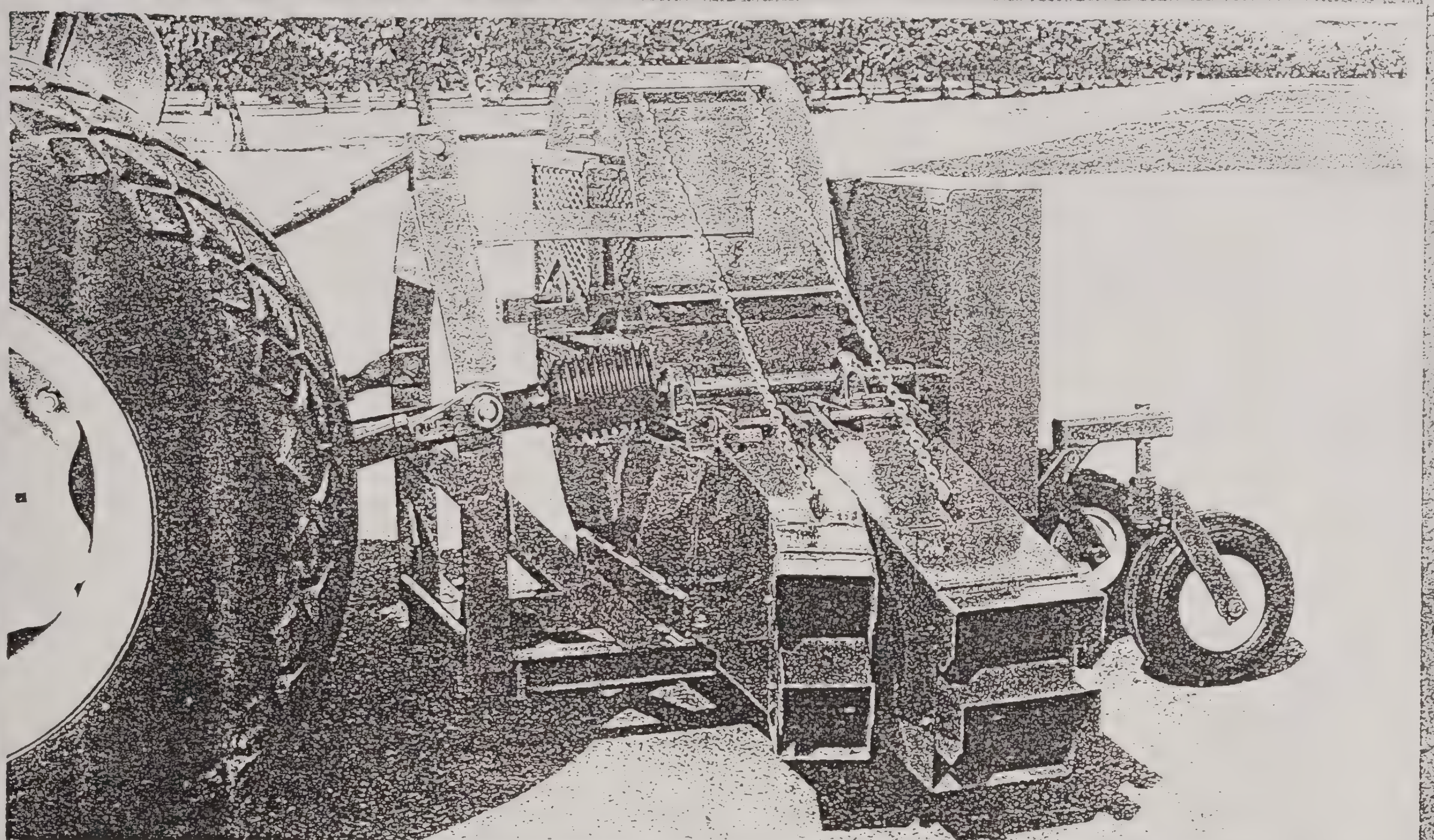
WITH THE PROVEN [illegible] CLEANING SYSTEM

The FLORY 7400 Series Self-[illegible] Harvester [illegible] Cleaning System [illegible] scrubbing action that provides [illegible] cleaning chain [illegible] high-volume, low velocity [illegible] dust generation and longer [illegible]

The placement of the [illegible]

[illegible]

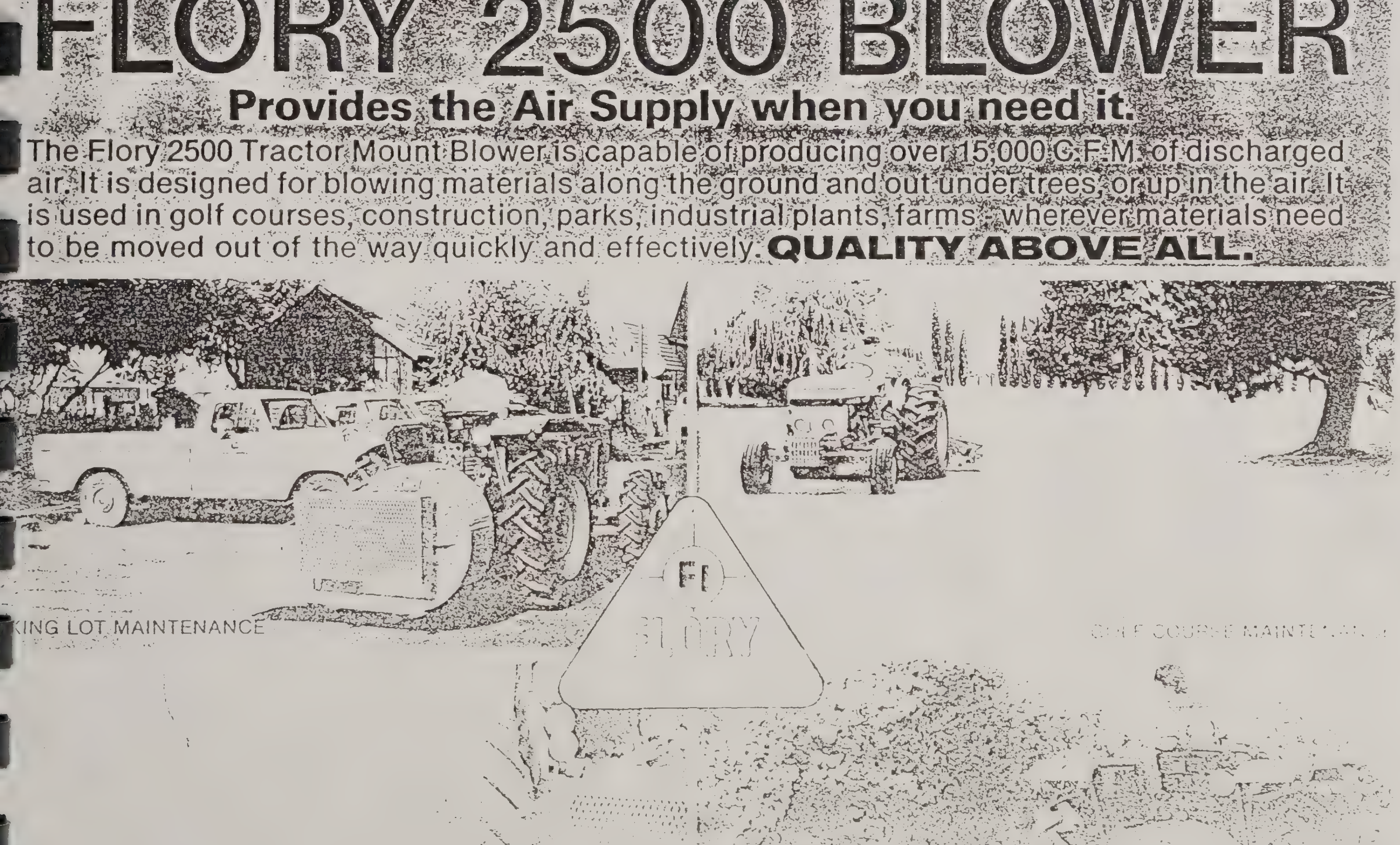
FOR A FAST FINISH . . . . . START WITH FLORY



FLORY 2500 BLOWER

Provides the Air Supply when you need it.

The Flory 2500 Tractor Mount Blower is capable of producing over 15,000 C.F.M. of discharged air. It is designed for blowing materials along the ground and out under trees, or up in the air. It is used in golf courses, construction, parks, industrial plants, farms - wherever materials need to be moved out of the way quickly and effectively. **QUALITY ABOVE ALL.**



KING LOT MAINTENANCE

Pacific Pavement Recycling, Inc.

EQUIPMENT SPECIFICATIONS
Asphalt Processing & Emission Controls

Equipment: Hot in-place asphalt recycling system
Manufacturer: Pyrotech Asphalt Equipment Mfg. Co. Ltd.
Make/Model: Pyropaver 300E Serial No. 300E-0006
Year of Manufacture: 1992

Process Information

The truck tows the Preheater, the first unit of the asphalt recycling train. This truck is outfitted with a specially designed second transmission which drops the gear ratio to enable a wide choice of reduced speeds of operation while maintaining normal rpm.

The Preheater applies the initial heat to the pavement surface. The heat source is provided by torches which are horizontally fired into a shrouded chamber creating air turbulence to aid in the moisture removal process. The asphalt surface does not receive direct flame at any time.

Steel wheels are used on the Preheater during operation. Although rubber tires are provided for transport, this unit is usually hauled on a flat deck.

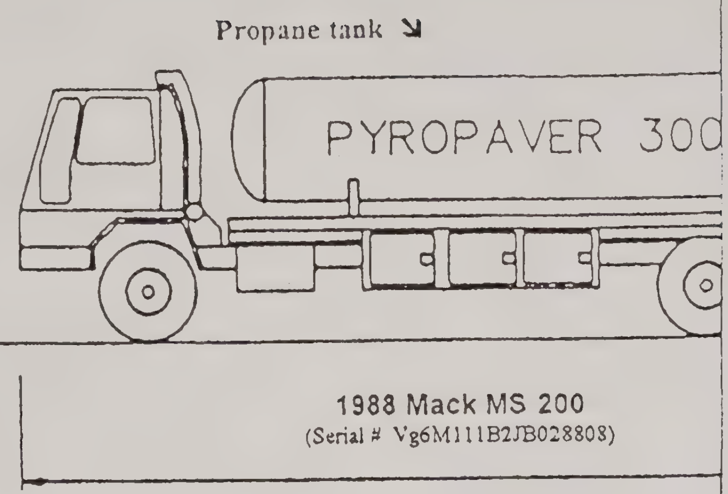
Emission Control System

The preheater truck carries the fuel source to operate the Preheater unit of the recycling system. The Preheater itself is designed to provide heat and air turbulence over the full width of the pavement lane (12'). Skirting around the 20 burners used in this initial phase of the recycling process is designed to skim the pavement surface to reduce fugitive emissions.

Air, steam and gases from the surface are propelled via normal convection currents into an interior combustion chamber. Three additional 500,000 Btu burners incinerate that air and its contents. Exhaust is by means of natural aspiration. Design opacity at stack exit is 10%.

The Preheater is the only unit of the system with dual stacks. All emission control stacks have double wall construction. Test probes must penetrate both walls to obtain accurate output data. Operating parameters of the emission control system are given at the far right.

PRE



1988 Mack MS 200
(Serial # Vg6M111B2JB028808)

PREHEATER TRUCK

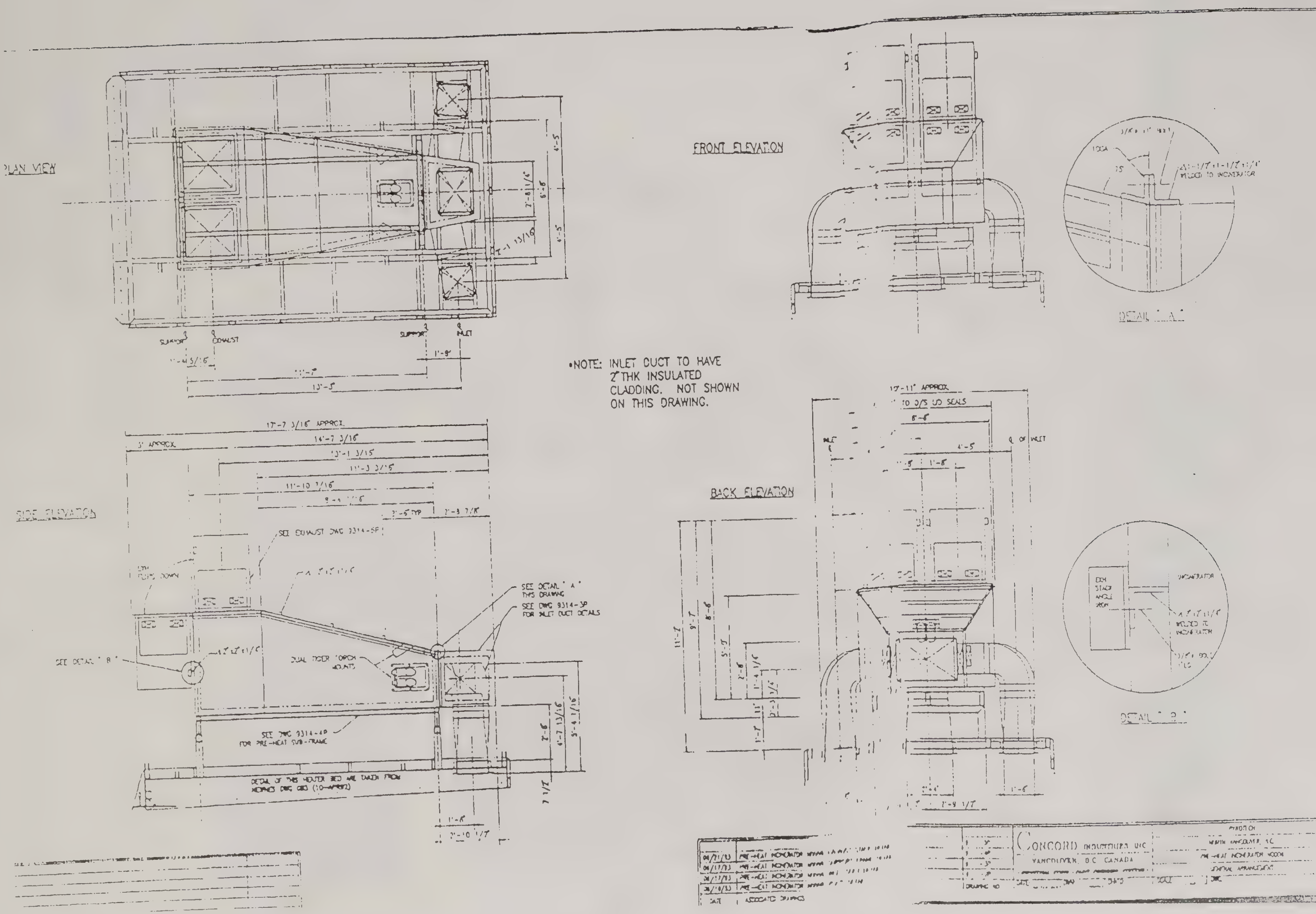
Dimensions:	Length: 24' Width: 8' 2" Height: 9' 6"
Axle weights:	Front: 12,000 lbs Rear: 21,000 lbs
Tires:	11R22.5 Load rating: 6,040 lbs @ 105 ps 2 on front axle; 4 on rear axle
Engine:	Diesel (376 cu in) Serial #: 026577K8 180 horsepower at 2500 rpm
Propane tank:	Manufactured by: Superior Pressure Vessels Capacity: 2000 USWG Serial #: 2N-012 / 2753506 MAUP 265 psi @ 200°F MDMT 20°F @ CRNK 6386.21 HEAD FA455 Thicknes Thickness .347 DIA 49 Length 256 S
Vaporizers:	Manufactured by: Algas Industries Model 80/40 Quantity: 2

☐ Returned for corrections
☐ Resubmit ____ copies for approval
☐ Submit ____ copies for distribution
☐ Return ____ corrected prints
☐ For review and comment
☐ For bids due ____ 19____
☐ Prints returned after loan to us
☐ ____

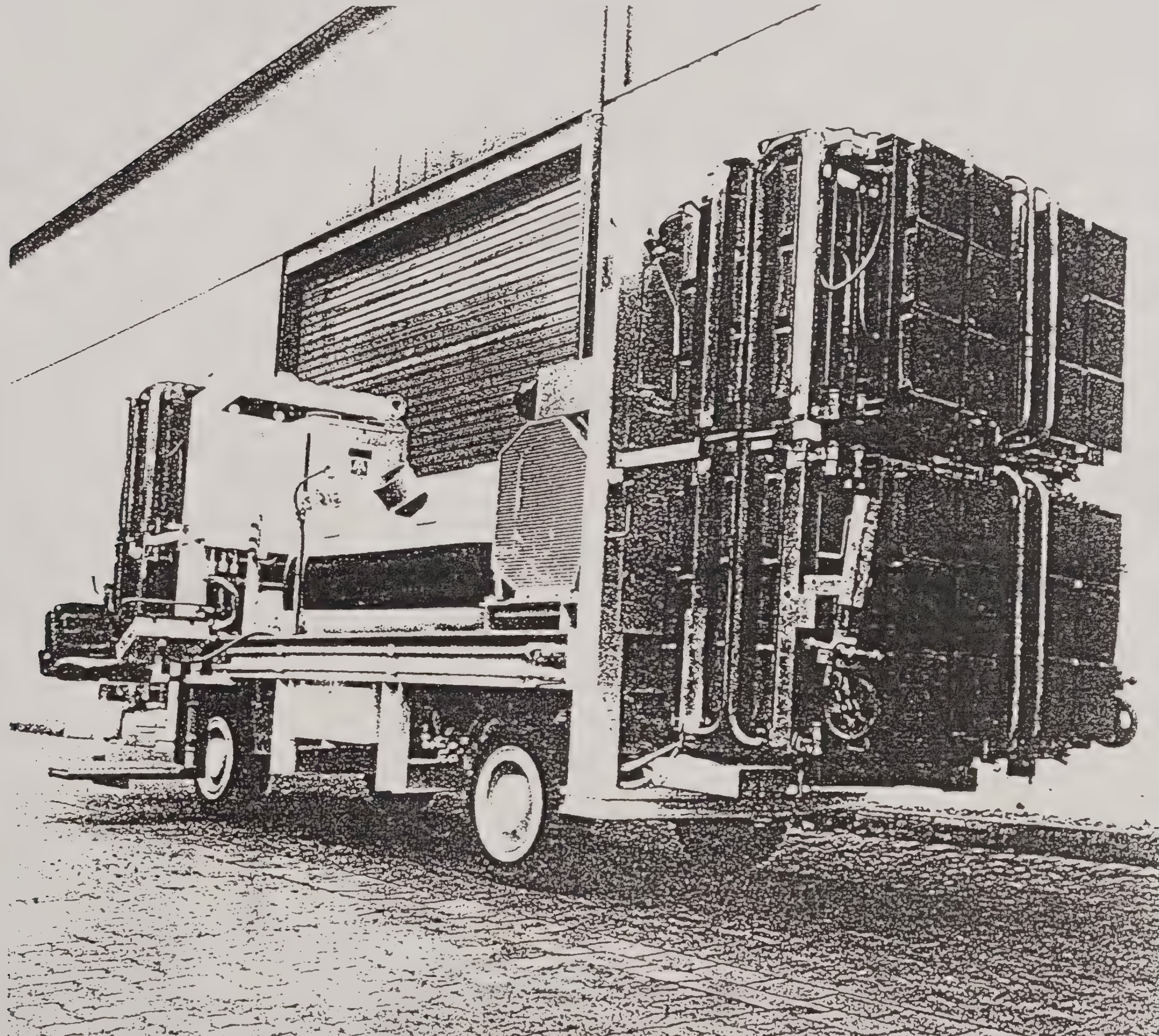
Recycling, Inc.
P.O. BOX 68785
SEATTLE WA
98168 0785
206/575-2473
FAX 206/575 4907
MARK SCOCCOLO
President

SIGNED: Mark Scoccolo

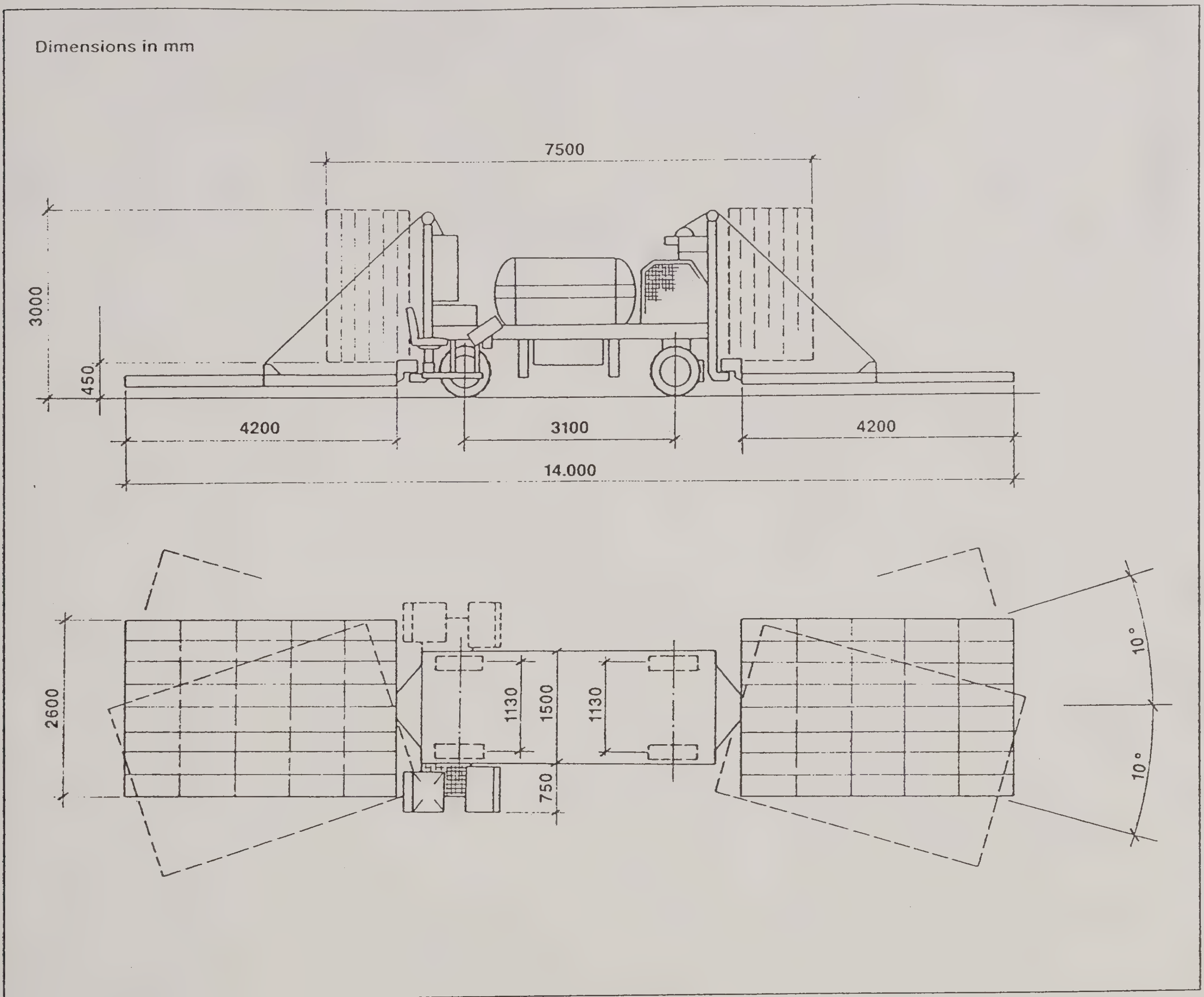
If enclosures are not as noted, kindly notify us at once.


PLAN VIEW
FRONT ELEVATION
DETAIL "A"
SIDE ELEVATION
BACK ELEVATION
DETAIL "B"
•NOTE: INLET DUCT TO HAVE 2"THK INSULATED CLADDING. NOT SHOWN ON THIS DRAWING.
SUPPORT
EXHAUST
INLET
17'-7 3/16" APPROX.
16'-7 3/16"
13'-5"
4'-5"
6'-8"
SEE EXHAUST DWG 9314-5P
SEE DETAIL "A" THIS DRAWING
SEE DWG 9314-3P FOR INLET DUCT DETAILS
DUAL TIGER TORCH MOUNTS
SEE DWG 9314-4P FOR PRE-HEAT SUB-FRAME
SEE DETAIL "B"
17'-11" APPROX
8'-8"
CONCORD INDUSTRIES INC
VANCOUVER, B.C. CANADA
DATE
ASSOCIATED DRAWINGS

Wirtgen



Panel heating machine
HM 2500
Technical Specification



Basic design

Self-propelled machine for thermal treatment of bituminous pavements. The HM 2500 is used to pre-heat and soften the existing bituminous surface prior to further processing stages.

Base frame

Rigid, welded frame of reinforced steel profiles with fixtures for the operational units and superstructure. All components are easily accessible for service and repair.

Axle suspension

The front axle is free-floating, and the rear wheels are rigidly connected to the base frame.

Steering

The machine is equipped with a finger-light hydraulic 4-wheel steering system. Both axles can be individually steered (crab steer).

Travel drive

The hub-mounted motors fed by a variable displacement pump which is flanged to the main engine. Travel and working speed are infinitely variable from zero to maximum speed.

Brake system

Braking is achieved by drag from the hydrostatic transmission.

Heating the pavement

The existing pavement is softened by infrared heaters. The energy source used is propane gas, which is vaporised and burnt in gaseous form.

Gas tank:	Liquid gas tank with level indicator.
Vaporiser:	One gas operated vaporiser with thermostatic control.
Heater elements:	Infra-red heaters.
Heating capacity:	Adjustable via pressure control valves.

The front and rear heater panels can be adjusted in height and slewed independ-

Bibliography

Ascard, J. 1988. Thermal Weed Control in Flame Treatment - a Useful Method for Row-Cultivated Crops and Haulm-Killing in Potatoes. Weeds and Weed Control. v.1 p.194-207. Uppsala: Dept. of Plant Husbandry and Research Info Ctr, College of Agriculture.

Baker, K.F., and W.H. Fuller. 1969. Soil heat treatment by microwave energy to destroy plant pathogens. J. Phytopathology. 59(2):193-197.

Barker, A.V., Craker, L.E. 1991. Inhibition of weed seed germination by microwaves. Agron J., American Society of Agronomy. Madison, WI. Mar/Apr, 83(2):302-305.

Bellusci, A.V. 1973. Thermal Brush Control. USDA Forest Service Equipment Development Center, ED&T 2168. Missoula, MT.

Cavanagh J.B., and R.R. Weyrick. 1978. Weed Burner for Controlling Undesirable Trees and Shrubs. J. Forestry 76(8):472-473.

Chinanzvavana, S., W.L. Grosshandler, D.C. Davis. 1986. Analysis of Heat Transfer in Soil During Open Field Burning. Nov-Dec. 29(6):1797-1801. American Society of Agricultural Engineers. St. Joseph, MI.

Bedard, W.D. 1966. High Temperature Mortality of the Sugar-pine Cone Beetle, *Conophthorus Lambertianae* Hopkins (Coleoptera: Scolytidae) The Canadian Entomologist Vol. 98:Feb. p.152-157.

de Forest, B. 1977. Field Burning by Air. Aerial Applicator. Jan/Feb 15(1):5-6.

Hillel, D. 1980. Fundamental of Soil Physics. Academic Press, NY. p.291-300.

Johnsen, J.O. 1981. Some Effects of a Moderate Intensity Prescribed Understory Burn on Seed Production and Losses to Insects in Seral Ponderosa Pine in Northern Idaho. MS Thesis. University of Idaho. Dept. of Forest Resources. 51p.

Lague, C., L. Chenard, P. Savard. 1992. Engineering Performance of Propane Burners Used for Weed and Pest Insect Control. American Society of Agricultural Engineers. Paper No. 92-1598, 12p.

Mellish, S.B. 1987. The Use of Prescribed Fire for Control of the Red Pine Cone Beetle in a New Brunswick Red Pine Seed Production Area. M.S. Thesis, Univ. of New Brunswick, 120 p.

Miller, W.E. 1978. Use of Prescribed Burning in Seed Production Areas to Control Red Pine Cone Beetle. Environ. Entomol. 7:698-702 (1978).

Miller, W.E. 1979. Fire as an Insect Management Tool. Entomological Society of America Bulletin, 25:137-140.

Mitchell, R.G. and R.E. Martin. 1980. Fire and Insects in Pine Culture of the Pacific Northwest. Proceedings Sixth Conference on Fire and Forest Meteorology. April 22-24, Seattle, WA. Published by: Society of American Foresters. p.182-190.

Parish, S. 1989. Investigations into Thermal Techniques for Weed Control. Proceedings of the 11th International Congress on Agricultural Engineering. Sept. 4-8, Dublin, Ireland. p.2151-2156.

Ou, L.T., D.F. Rothwell, M.V. Mesa. 1985. Soil Sterilization by 2450 Mhz Microwave Radiation. Soil and Crop Science Society of Florida. 44:77-80.

Van Wagner, C.E. 1970. Fire and Red Pine. Tall Timbers Fire Ecol. Conf. Prod. p.211-219.

Van Wagner, C.E. 1970. Temperature Gradients in Duff and Soil During Prescribed Fires. Can. Dept. Fish. For. Bi-Monthly Research Notes, 26:42.

Wade, D.D., G.L. Debarr, L.R. Barber, E. Manchester. 1989. Prescribed Fire - A Cost Effective Control for White Pine Cone Beetle. Presented at the 10th Conference on Fire and Forest Meteorology, April 17-21, Ottawa, Canada.

Trip Report
Site visit to Beaver Creek Seed Orchard
April 19, 1994

Keith Windell, MTDC Project Engineer

INTRODUCTION

As part of the MTDC "Thermal Insect Control" project (TA&S# 3E32P11) Keith Windell traveled to the Beaver Creek Seed Orchard (Corvallis, OR) to inspect two pieces of equipment which are being tested to lower populations of the Douglas-fir seed cone gall midge and Douglas-fir seed chalcid in the orchard. The basic idea is to kill the midges or chalcids while they are overwintering in the litter/duff layer of the orchard floor. Two approaches are being evaluated at the orchard. The first is a thermal treatment using a prototype liquid propane burning device which was developed by the Rears Manufacturing Company (Salem, OR). The second is a modified flail mower under development by the same company. Evaluation of these machines is being undertaken in a joint effort between Roger Sandquist & Pete Owston (FPM, Portland), Tim Schowalter (Oregon State University), and Bill Randall & Kim Brown (Siuslaw N.F.).

BACKGROUND

Tim Schowalter wrote the initial test plan (appendix). He had previously conducted a series of lab experiments to determine temperature and duration requirements to cause mortality in the midges. Anticipated propane burner temperatures were obtained from an unpublished field burning experiment by Chilcote and Youngberg (appendix). 50 degrees Celsius (at the lower duff level) was thought to be a minimum temperature necessary to be effective. A first attempt to burn took place in March. Roger Sandquist, Tim Schowalter, Bill Randall, Kim Brown, and Jim Rears, Sr. were in attendance.

The experimental machine used 5 flame nozzles and was set for a propane application rate of about 30 gallons per acre at 4 miles per hour. Five nozzles were mounted on a six foot wide bar. Nozzle angles tested were between 45 degrees and parallel to the ground (pointed in the direction of travel). It was felt that 45 degrees to the ground was the most effective. The prototype flamer had a preheating chamber ahead of the nozzles. The volume of this chamber could be adjusted. A curved hood was located at the front of the machine which allowed smoke to escape. Thermocouple readings indicated only 50 degrees Celsius on the surface and 14 degrees Celsius under 2-3 cm of litter. The experimental plots were not put in because of insufficient temperature elevation.

It was thought that if the duff layer could be pulverized prior to the burning, by a flail mower, chances for success would be greatly increased. It was speculated that perhaps the burning treatment would be enhanced and perhaps the insects might even be killed by the chopping action. Jim Rears was working on a modified flail mower to aid in the rapid decomposition of straw stubble, and made it available for the groups evaluation. The mower has 24 knives per foot and is 6 feet wide. The mower is powered off the tractors PTO which turns at 540 RPM and has a gear increase of 4:1. This means the drum that holds the knives turns at 2160 RPM. It was found out quickly that the orchard's 1250 John Deere tractor (45 hp) was under powered for the job. Due to the uneven nature of the orchard floor the knives would occasionally dip deep into the soil and stall the engine. Jim Rears figured at least an 85 hp tractor would be required to pull the whole 6 foot width. To install the plots, the 2 foot center section of knives was removed. Kim Brown used the modified flail mover to install 5 paired plots on April 5th.

Tim Schowalter installed emergence traps over the plots as well as on control plots. Traps consisted of galvanized sheet metal boxes (about an 18" cube) with an air vent on one side and a glass collection jar on the opposite side. The idea is after the midges emerge they will go to the light in the jar and be counted. The mechanical disruption of the litter/duff layer will be evaluated separately.

SITE VISIT

The day I visited the orchard Bill Randall, Kim Brown, Tim Schowalter, and Yan Li (Graduate student from China) were also in attendance. The purpose of my visit was to become acquainted with the people involved, the equipment being tested, and the orchard layout. Not only did I get to see how the equipment operated but we were also able to get a few temperature readings from the flamer. We did not however install any experimental plots.

The orchard is comprised of 50 acres of Douglas-fir. Trees are 35- 40 feet tall (almost too tall for orchard maintenance). Portions of the orchard are being cut out and replanted. Besides coastal Douglas-fir there will also be a small plot of Western White Pine for the Willamette N.F. in the future. Trees present are planted on about 25-30 foot centers and are pruned up about 6 feet. Duff layer on the orchard floor is about 1/2-3/4 inch deep. There is also green grass and moss present on the site this time of year.

I was interested in simulating two different scenarios. One where the flamer would be used on the undisturbed orchard litter/duff layers, and the other where the flail mower would pulverize the litter/duff layer prior to the burn. The thermal data were collected by a Campbell's Scientific 21x data logger. Unfortunately we

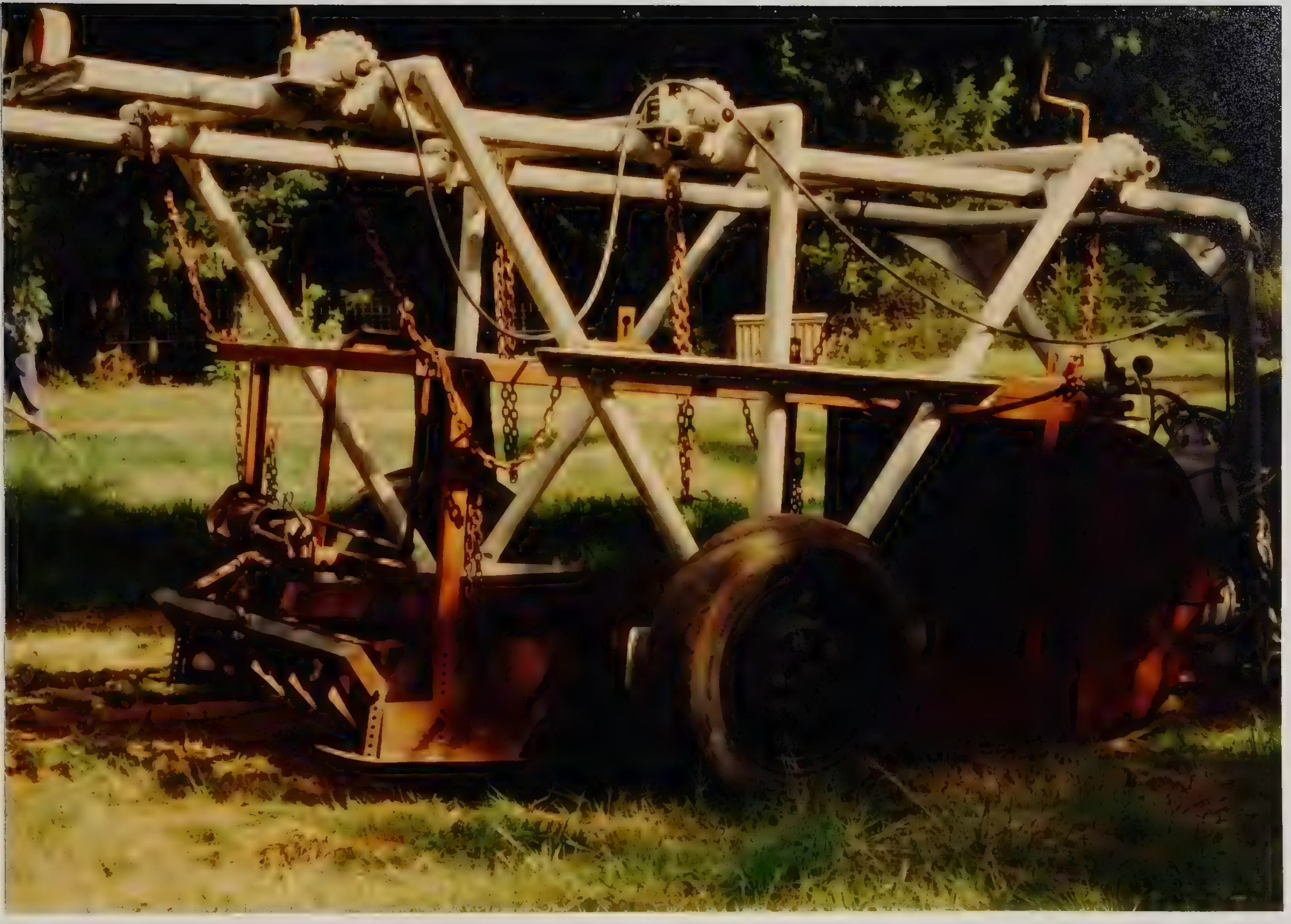
were not set up to measure soil temperature. Tim Schowalter generated time-temperature curves from the data [located after discussion section].

DISCUSSION

The field data will be compared to the lab results generated by Professor Schowalter to see if we are even close to achieving the necessary heating. If we are close to the desired temperature regime, ways to enhance the burning will be sought. If we are not close, other schemes may have to be developed (i.e. steam treatments, microwaves).

The cooperative group plans to install more study plots in the fall - most likely September. I believe treatments will include flaming, pulverizing, flaming + pulverizing, and control. They plan to use a larger tractor so that the pulverizing can be accomplished easier. After discussing the need to minimize the duff layer prior to propane burning, it was proposed that a broadcast burn in the early fall, when the grasses and mosses are cured, may be highly beneficial and cost effective. The burned area will be created before the midges drop to the orchard floor but still may be effective for two reasons. It may create a hostile environment for the dropping midges and it will reduce the litter/duff layer for the upcoming spring propane burn. This may or may not become one of the treatments in the experimental design.

When asked how MTDC might be of assistance for the fall treatments, Bill Randall mentioned the need for more data collection systems. Possibly 6 data loggers with thermocouples.



FLAMER

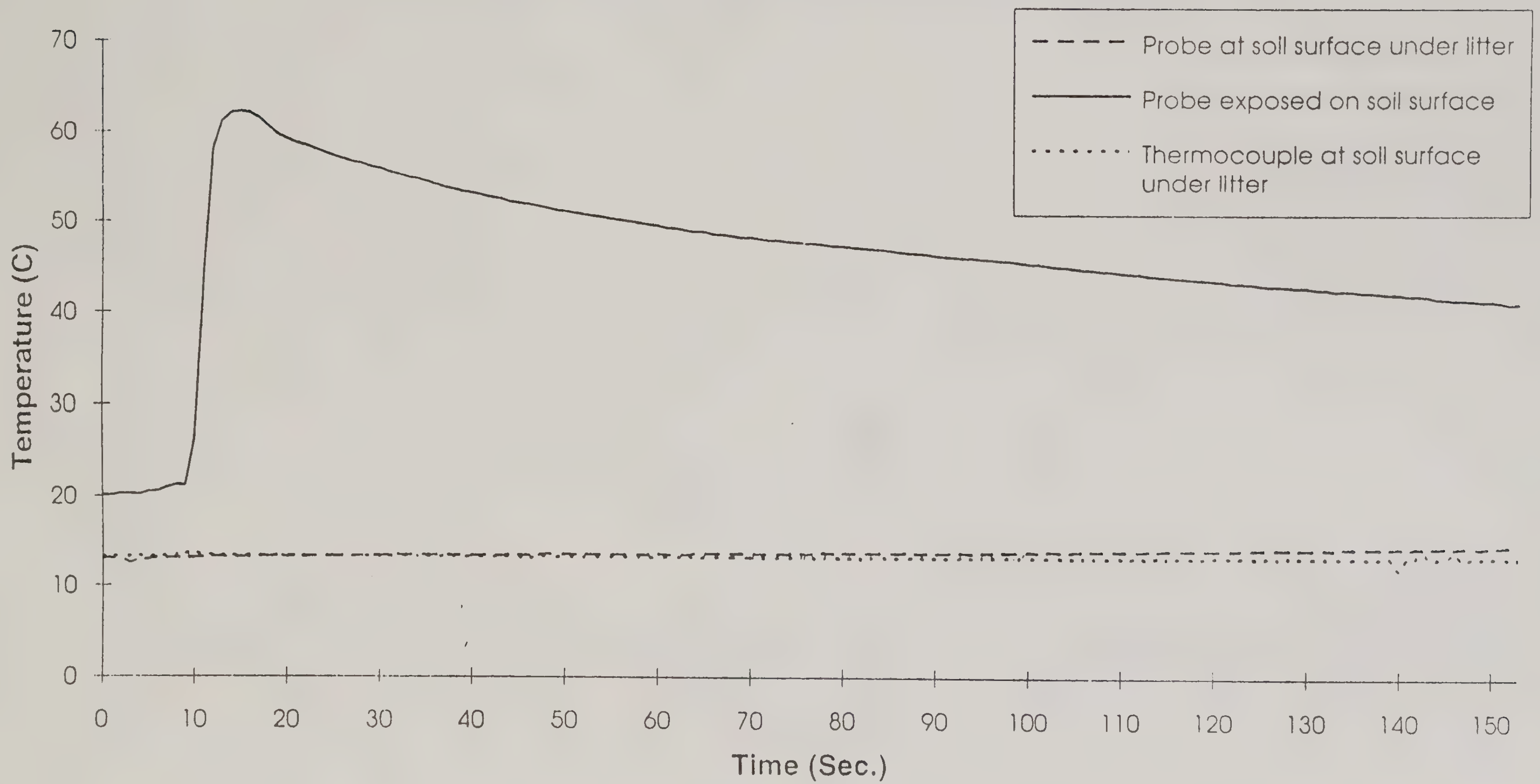
MODIFIED FLAIL MOWER

Beaver Creek Seed Orchard
Temperature Data
April 19, 1994

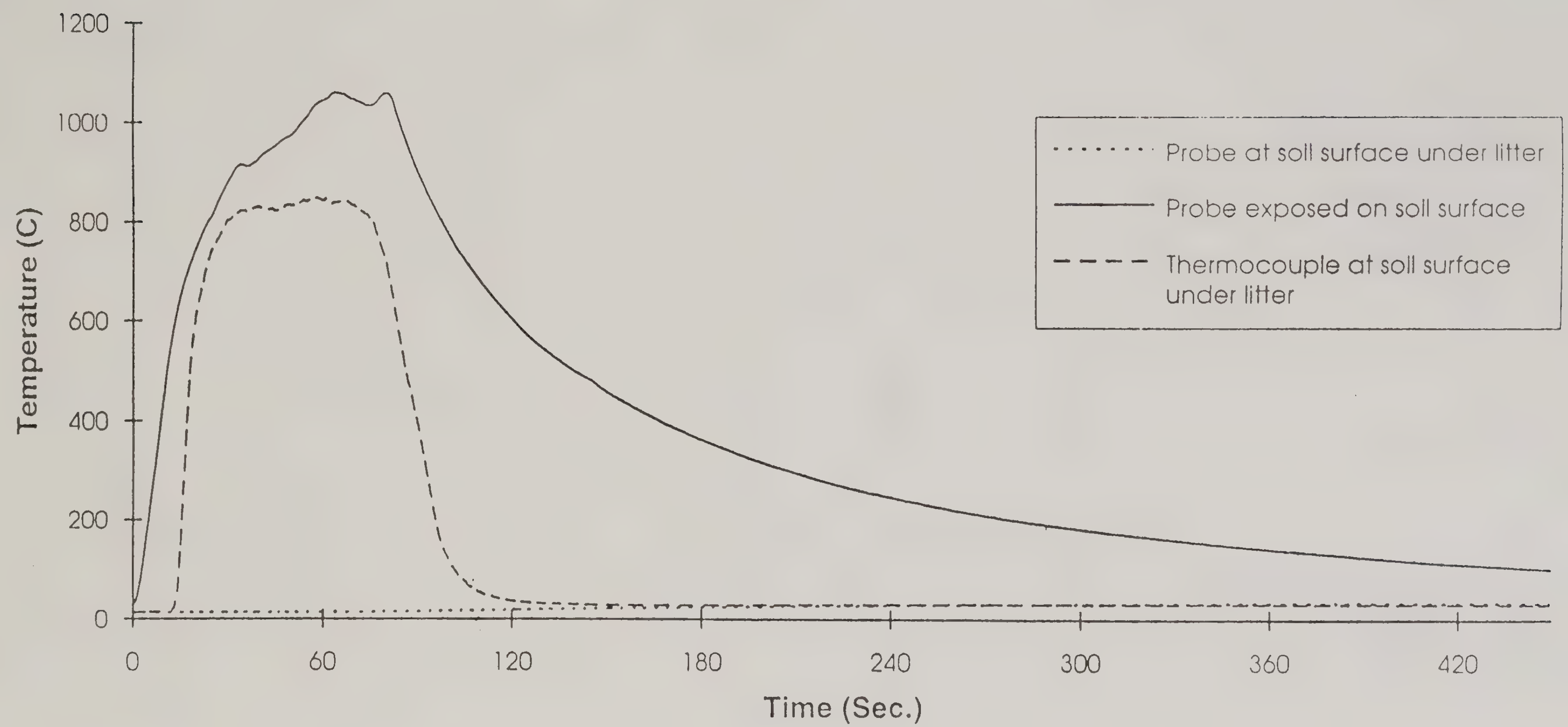
Undisturbed Orchard Floor (green grass/moss/duff)			Pulverized Litter/Duff Layer		
	Moving Tractor (1 mph)	Parked Tractor	Moving Tractor (1 mph)		Parked tractor
Matted duff/litter Depth	1.3 cm (1/2")	1.3 cm (1/2")	.3 cm (1/8")	.3 cm (1/8")	.6 cm (1/4")
P1 Temp	13C (2)	1050C (1)	216C (1)	92C (1)	900C
P2 Temp	63C (1)	-------	25C (2)	57C (3)	125C
P3 Temp	13C (2)	800C (2)	28C (2)	22C (2)	980C

P1 - Shielded K-type thermocouple
P2 - Shielded K-type thermocouple
P3 - Glass insulated K-type thermocouple
(1) - Located on surface
(2) - Located at duff/soil interface
(3) - Located under 1" of fluffed duff

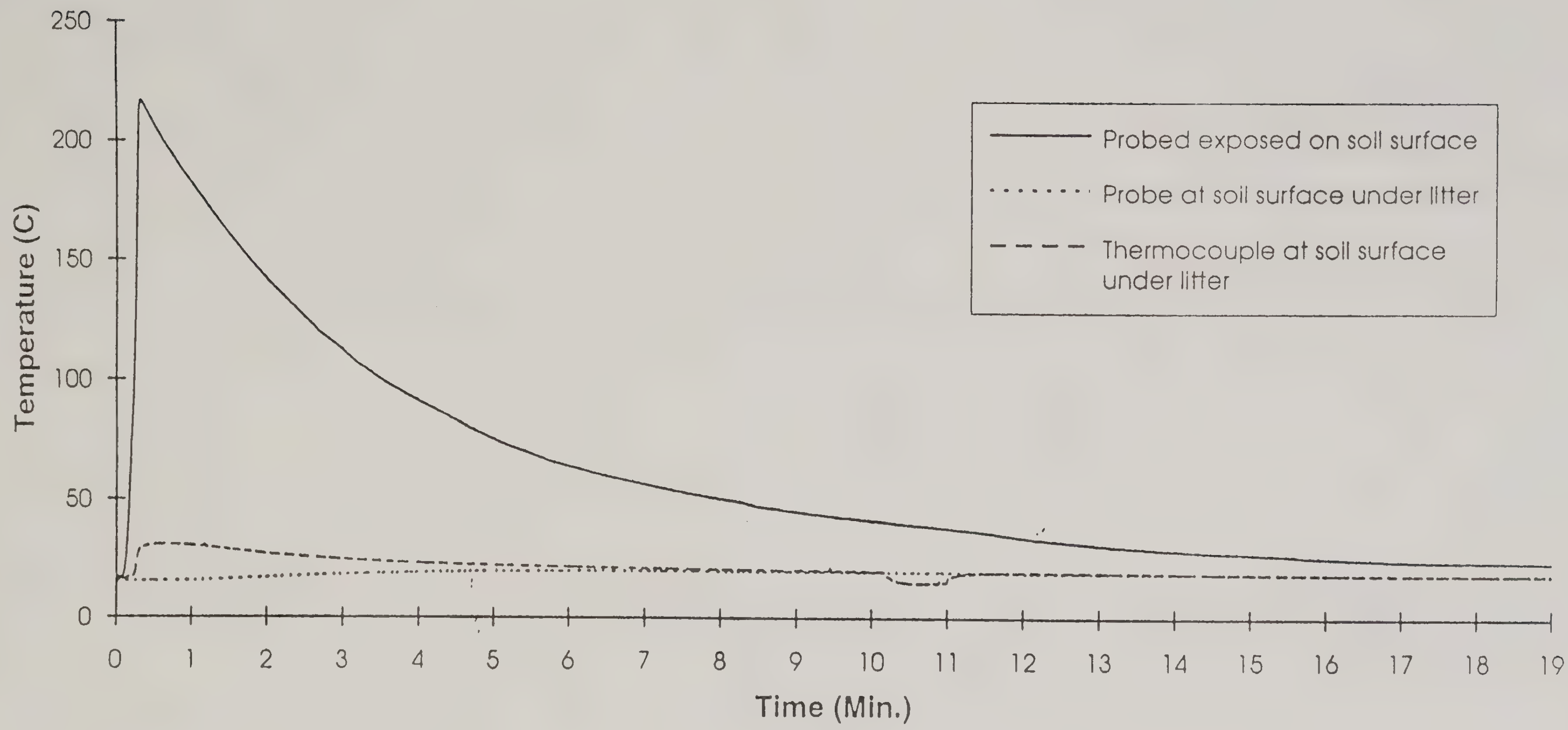
Temperature Profiles from Flaming Unchopped Grass



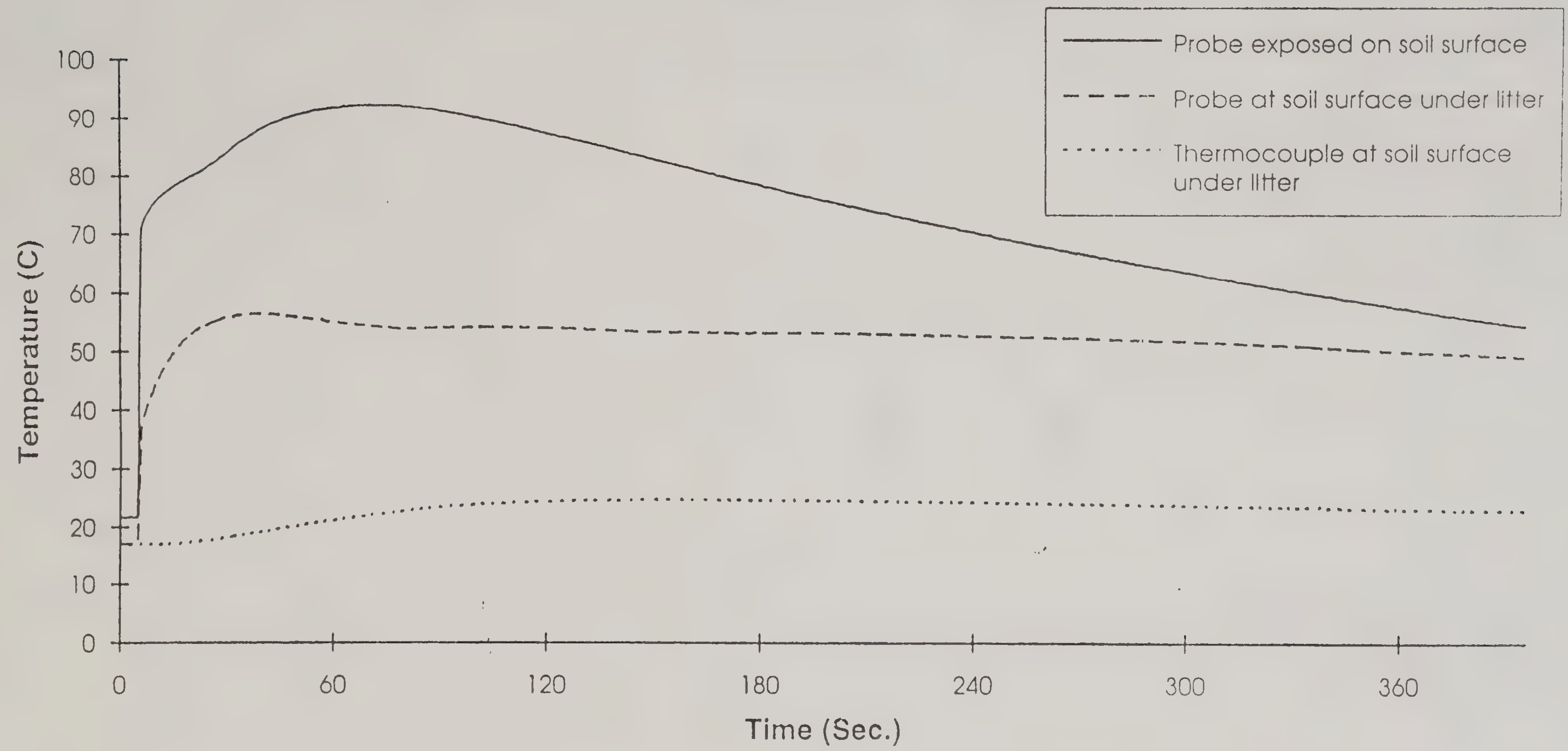
Temperature Profiles from Stationary Flamer over Unchopped Grass



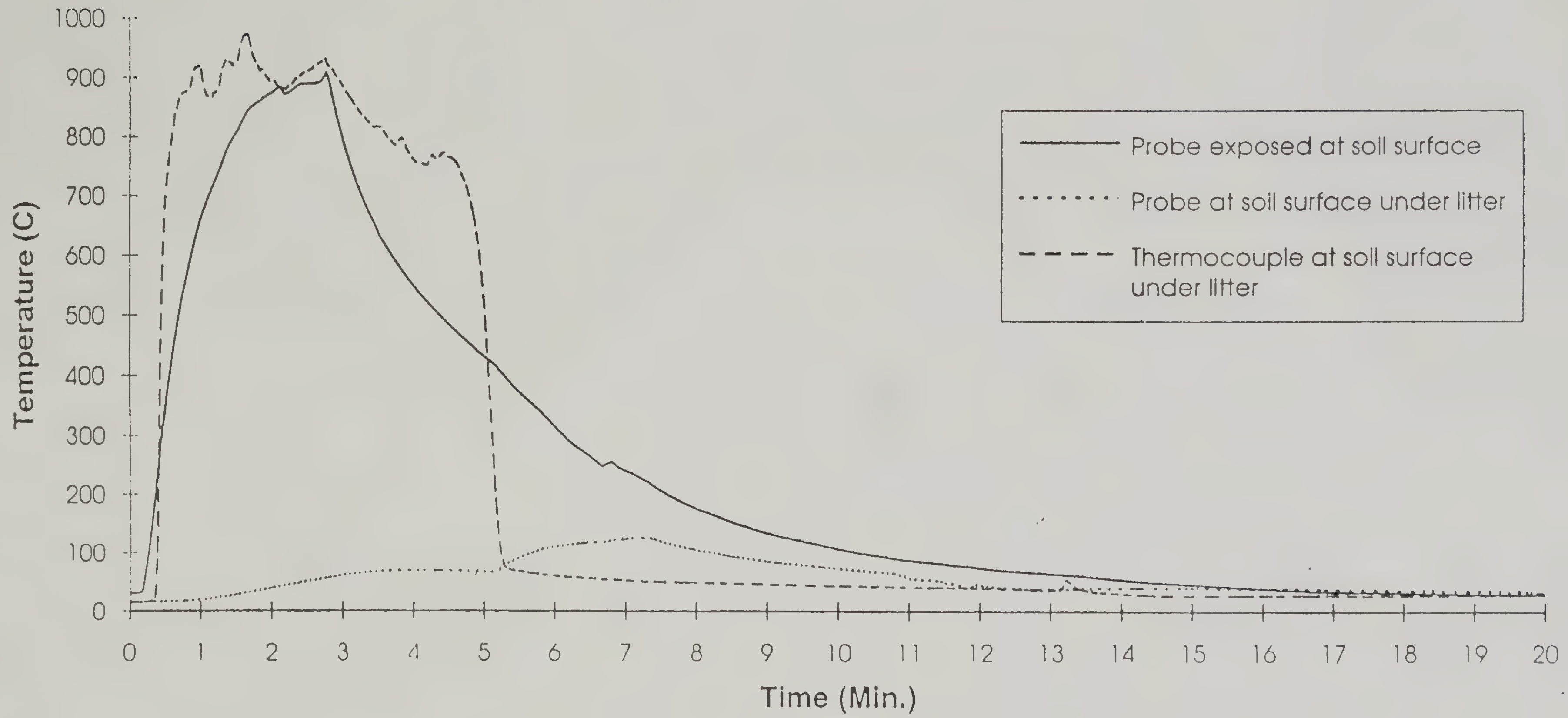
Temperature Profile from Flaming Chopped Grass



Temperature Profiles from Flaming Chopped Grass



Temperature Profiles from Stationary Flamer over Chopped Grass



DEPARTMENT OF
ENTOMOLOGY

OREGON
STATE
UNIVERSITY

Cordley Hall 2046
Corvallis, Oregon
97331-2907

Telephone
503-737-4733

Fax
503-737-3643

Internet:
entoffice@bcc.orst.edu

12 October 1993

Mr. Keith Windell
USDA Forest Service
Missoula Technology & Development Ctr.
Ft. Missoula, Bldg. 1
Missoula, MT 59801

Dear Keith:

Enclosed is a draft study plan for the project to evaluate burning for control of cone and seed insects. Roger and I are planning on using a 6' wide, 6-burner flamer, perhaps with extensions to widen the burn swath if these are available. We also are exploring an additional treatment using a brush mill to grind litter without burning, if we can obtain this equipment. We plan to start the study in November at Beaver Creek Seed Orchard near Corvallis.

Please let me know if you have any comments or suggestions for our proposed study. We would welcome your involvement if you are interested.

Sincerely,

Tim

Timothy D. Schowalter
Professor

cc: R. Sandquist

USDA Forest Service Cooperative Agreement PNW 92-0209
Evaluation of Burning to Reduce Overwintering Populations of Gall Midge Pupae and Seed Chalcid Larvae
FY 1994 Study Plan

T.D. Schowalter
Entomology Department
Oregon State University
Corvallis, OR 97331-2907
and
R.G. Sandquist, P.W. Owston and W.K. Randall
USDA Forest Service

Previous Work

This project was initiated in June 1992 for the purpose of evaluating the effectiveness of burning as a means of controlling Douglas-fir cone gall midge, Contarinia oregonensis Foot, and Douglas-fir seed chalcid, Megastigmus spermotrophus Wachtl, in seed orchards. These insects are the two most destructive species associated with reduced seed yields in Douglas-fir seed orchards in western Oregon (Dombrosky and Schowalter 1988, Schowalter et al. 1985). Because of their cryptic habits, few non-chemical tactics for controlling populations of these species are available. However, their habit of overwintering in litter under host trees makes them vulnerable to burning. Prescribed burning has been used successfully to control populations of cone beetles and coneworms in eastern pine seed orchards (e.g., Miller 1978, 1979).

Initial investigation has focused on the thermal tolerance of gall midge larvae in the laboratory. Larvae were obtained from the Weyerhaeuser seed processing facility in Rochester, WA in fall 1991. Larvae were stored in a moist plastic bag in a refrigerator at 4° C. These conditions simulated the cool, moist litter conditions prevailing during winter. Groups of ten active larvae were placed on either dry or saturated, surface dry filter paper in separate Petri dishes. Saturated, surface dry filter paper was prepared by soaking filter paper in water and then hanging until dripping ceased. This treatment was intended to simulate moist litter conditions prevailing during the overwintering period.

Heat treatments were selected to simulate various burning intensities and durations suggested by temperature profiles measured in grass field burning studies (Chilcote and Youngberg unpubl. data, Appendix 1). For propane flamers propelled at 1.6-2 kph, temperatures reached 340-490° C, with temperatures of at least 200° C sustained for at least 15 sec., and temperatures of at least 100° C sustained for 20-30 sec. Therefore, larvae were tested both at constant temperature for varying durations and at declining temperature, accomplished by moving dishes from an oven at higher temperature to an oven at lower temperature. Test Petri dishes were placed in the oven at the selected temperature regime, then removed and returned to the refrigerator. Control Petri dishes were returned to the refrigerator without heat treatment. Larvae still active were counted 15 min., 2 hr and 1 d after treatment and percent mortality recorded.

Midge mortality increased as temperature and duration of

heat exposure increased and was maximized under dry conditions (Table 1). Control larvae in Petri dishes returned to the refrigerator showed no mortality for up to five days, but suffered mortality reaching 100% by the eighth day when the filter paper had dried out. Thus, dessication appeared to be as effective as heat in reducing survival, and might complement flaming as heat both immediately kills larvae and dessicates the substrate.

Planned Work

We had considered conducting further detailed studies of effects of litter depth and moisture to indicate conditions under which flaming would be most effective. However, we believe that an operational test in a candidate seed orchard with treatments designed to assess effects of burning time, and perhaps litter depth, would accomplish our objectives and also indicate technical feasibility. We propose the following studies.

The USDA Forest Service Beaver Creek Seed Orchard near Corvallis is a convenient seed orchard to use for study. Blocks are sufficiently large for treatment replication and other activities will not confound results of our experiments. In addition, cones were not harvested in 1993, ensuring resident cone and seed insect populations under productive trees. A potential problem is the proximity of natural sources of cone and seed insects outside the orchard and from untreated control plots. Schowalter (1984) reported that the midge and chalcid infested cones over a distance of at least 100 m. We anticipate that cone and seed insects primarily attack cones of trees near the emergence site. We will address this potential problem by separating treatment plots as much as possible from expected sources of insects and by measuring insect emergence under treated trees, to assess treatment effects on survival and emergence, as well as measuring cone and seed development.

Timing of burning treatment is critical to successful control of overwintering cone and seed insects in this region, given the often saturated litter conditions that could reduce mortality (see results of Previous Work). Therefore, we will burn at two different times during the overwintering period: November 1993 and February 1994. These times were selected to represent the early wet season (November) when midge larval emergence from cones should be nearly complete and litter still relatively dry, and late winter (February) when dry conditions often occur and midge adults have not begun to emerge. We will establish 40 treatment plots, roughly 60 x 60 m, to include 25-30 trees, or as determined during pretreatment orchard survey. These plots will be randomly allocated to four treatments: untreated control, burned November, burned February, and burned November and February. The twice burned treatment will indicate if additional burning increases efficacy.

Burning will be accomplished by passing a propane flame over the treatment plots at the scheduled times. A 6-burner (perhaps larger) tractor-drawn trailer is available for rent (in Eugene, OR) and will be pulled at 1 mph over the designated area, as described by Chilcote and Youngberg for treatment of grass fields (unpubl. data, Appendix 1).

[illegible]

surface.

Planting Time

[illegible]

Timing of watering treatment is critical to success [illegible]

[illegible]

November [illegible] 1984. These [illegible] were collected [illegible]

[illegible]

Collectors under 1-2 treated trees per plot will be used to measure midge drop to the litter in the fall. Emergence traps will be used to measure midge and chalcid emergence from the litter in the spring. Conelet examination will be used to measure midge oviposition, and cone dissection will be used to measure seed loss to the midge and chalcid (Dombrosky and Schowalter 1988, Schowalter et al. 1985). These measurements will be compared among treatments using one-way ANOVA to evaluate effect of burning on midge and chalcid populations and seed production.

Timetable

Oct-Nov 1993	Monitor midge larval drop to litter; establish treatment plots
Nov 1993	Burn designated orchard plots
Feb 1994	Burn designated orchard plots
Mar 1994	Monitor midge adult emergence and oviposition
Apr-Aug 1994	Monitor cone development
Aug-Oct 1994	Measure seed yield and loss to insects
Nov-Dec 1994	Analyze data and prepare papers for publication

Literature Cited

Dombrosky, S.A. and T.D. Schowalter. 1988. Inventory monitoring for estimation of impact of insects on seed production in a Douglas-fir seed orchard in western Oregon. J. Econ. Enomol. 81:281-285.

Miller, W.E. 1978. Use of prescribed burning in seed production areas to control red pine cone beetle. Environ. Entomol. 7:698-702.

Miller, W.E. 1979. Fire as an insect management tool. Entomol. Soc. Amer. Bull. 25:137-140.

Schowalter, T.D. 1984. Dispersal of cone and seed insects to an isolated Douglas-fir tree in western Oregon. Can. Entomol. 116:1437-1438.

Schowalter, T.D., M.I. Haverty and T.W. Koerber. 1985. Cone and seed insects in Douglas-fir (Pseudotsuga menziesii (Mirb.) Franco) seed orchards in the western United States: distribution and relative impact. Can. Entomol. 117:1223-1230.

Table 1. Mortality of Douglas-fir cone gall midge larvae under different conditions of temperature and duration of exposure. Mean ± SEM (N=6).

Filter Paper	Temperature (°C)	Time (sec.)	% Larval Mortality after 15 min.	2 hr.	1 day
Dry	100	15	100 (0)	100 (0)	100 (0)
Moist	50	15	30 (2)	23 (6)	32 (5)
Moist	200	5	0 (0)	3 (2)	10 (4)
Moist	200 80	10 10	7 (5)	8 (5)	13 (6)
Moist	200 80	15 15	43 (13)	43 (13)	43 (13)
Moist	200 80	20 15	87 (9)	87 (9)	88 (10)
Control	4		0 (0)	0 (0)	0 (0)

DEPARTMENT OF
ENTOMOLOGY

OREGON
STATE
UNIVERSITY

Cordley Hall 2046
Corvallis, Oregon
97331-2907

Telephone
503-737-4733
Fax
503-737-3479
Bitnet
ENTO@ORSTVM
Internet
e@ENT.ORST.EDU

14 April 1994

Mr. Keith Windell
USDA Forest Service
Missoula Technology & Development Ctr.
Ft. Missoula, Bldg. 1
Missoula, MT 59801

Dear Keith:

Here is the Chilcote and Youngberg report on grass field flaming temperature profiles and the clearest profile we obtained burning wet litter in the seed orchard using K-thermocouple housed in a stainless steel probe.

I hope we have a chance to work together to improve our flaming efficiency.

Sincerely,

Timothy D. Schowalter
Professor

AGRONOMIC CROP SCIENCE REPORT

Research Extension

PROPANE FLAMER BURNING OF GRASS SEED FIELD STUBBLE 1/

D. O. Chilcote and H. W. Youngberg 2/

Introduction

Alternatives to open burning of grass seed fields after harvest include the possibility of the use of other heat sources, such as propane or diesel, to provide the thermal sanitation so beneficial to seed production. Propane flamers are presently used in mint fields for control of disease pests, however, in this case, removal of residue is not the issue but rather destruction of the pathogens within the plant tissue. Obviously, such a treatment could only be considered where a large portion of the straw would be mechanically removed prior to use of the flamer for burning remaining residue.

The flamer (burning propane) ignites the stubble remaining after removal of the straw, so that residue burning is facilitated over a wider range of environment conditions and provides the thermal treatment normally achieved in an open burn. With most of the residue removed, the potential for emission of pollutants from burning is greatly reduced. To ascertain the possible use of such an alternate heat source for thermal sanitation of grass fields, studies were undertaken comparing propane flamer burning with open burning. Most of the residue down to a 2-inch stubble height was removed by flail-chopping prior to flamer treatment. An estimated 3/4 ton of residue remained on the fields. Time of season and grass species, as well as speed of operation, were variables in these investigations. Of course, variation in residue load would affect fire spread, as well as soil surface temperature.

Results

The use of a propane flamer to burn grass seed field stubble is a high cost operation requiring the removal of residue to leave as little fuel as possible on the soil surface. The operation can also be hazardous because of risk of fire spread, depending on humidity and wind speed. Environmental conditions were found to influence the effectiveness of the treatment.

1/ Progress Report EXT/ACS 3, Agricultural Experiment Station, O.S.U. 3/75

2/ Professor of Crop Physiology and Extension Agronomist, respectively, Department of Agronomic Crop Science.

Season of Treatment. Early propane burning is more beneficial than late burning, probably because of the presence of a lesser amount of green regrowth with higher moisture content and the higher moisture content of straw which is likely to occur later in the season (Table 1). Early propane flaming treatments resulted in seed yield response which compared favorably with open burn treatments (see Table 2). In almost every case, the seed yield with propane flaming was equal to or better than conventional open burning.

Table 1. Seed yields in four grass species when propane flaming 3/ was used early (August) versus late (October), 1967-68.

Species	Seed Yield (lbs/A)	
	Early	Late
Chewings Fescue	809	288
Perennial ryegrass	1221	763
Orchardgrass	1049	1149
Merion bluegrass	1200	967

Temperature and Speed. The results from studies on temperatures produced versus speed of operation indicate that the faster the operation the lower the temperature (Figure 1) perceived at soil surface and the shorter the duration of the temperature. A low temperature for a short period would be a concern in terms of effective sanitation. The temperature exposure from propane flaming may not be sufficient to destroy disease organisms and an increase in disease infestation might occur. No effort was made to evaluate disease control in this study since the fields were quite gree of disease from previous burning history. Open field burning shows quite a different temperature exposure pattern compared to flaming (Figure 2). Although temperatures may not be any higher, they are maintained for a longer period of time. The demonstration of survival of organisms (weed seed) on the soil surface lends further credance to the possibility that disease control would be inferior to open burning.

Smoke Emission. The technique of propane flamer burning of grass seed field stubble may contribute copious amounts of smoke because of the incomplete combustion of residue and smoldering after passage of the flame front. 4/ In addition, the smoke is retained at a low level in the atmosphere. The fate of this smoke and its effect remain to be assessed. Total emissions should be reduced because only a portion of the total residue is burned.

3/ Straw and stubble were chopped and removed prior to flaming and burning remaining residue.

4/ The amount of smoke produced would depend on the condition of the straw, regrowth, and the climatic condition, all of which influence the combustion process.

Table 2. Seed yields for five grass species when propane flaming was used, 5/ expressed as a percent of early open burn yields.

Species	Percent of early open burning
Chewings fescue	100
Creeping red fescue	90
Orchardgrass	101
Merion bluegrass	102
Highland bentgrass	108
Mean	100

Annual Versus Perennial Grass Crops. At present, burning of the residue after harvest is a primary method of weed control in annual ryegrass. Burning destroys the viability of seed on the surface of the soil. Studies with annual ryegrass showed that the temperature level and duration for propane flaming (approx. 2 1/2 mph) were not sufficient to destroy many of the weed seeds left in the fields after harvest and therefore a concomitant increase in weed infestation was noted. In fact, some promotion in the germination rate of weed seed was observed.

In perennial crops where herbicides are used extensively for weed control, propane flaming may be a more feasible alternative since it does remove the remaining residue after flail-chopping and removal of the straw, and appears to maintain seed yields. Where disease control may be less critical and for varieties or species sensitive to open burning, propane flamer burning may be a viable management practice for maintaining high seed yield. The technique might be particularly adaptable to the "close-clip" system of residue removal to provide an added measure of sanitation.

Conclusions

A propane flamer can be used to burn the residue remaining in seed fields after mechanical removal of straw and stubble. It seems most feasible in perennial grass crops, particularly those sensitive to burning, but has a high dollar and energy cost as compared to open burning. Early season treatment is most effective. Slower operating speeds provide the most effective thermal exposure.

5/ Straw and stubble were chopped and removed prior to flaming and burning remaining residue.

Propane flaming at rates above 2 mph in annual ryegrass failed to destroy weed seeds. This apparent limitation in thermal treatment also casts doubt on the ability of the flamer to destroy disease organisms, important in grass seed production. If the speed of travel is slow enough, satisfactory sanitation might be obtained. Smoke emission, although reduced, is still a problem and it is confined to lower levels of the atmosphere.

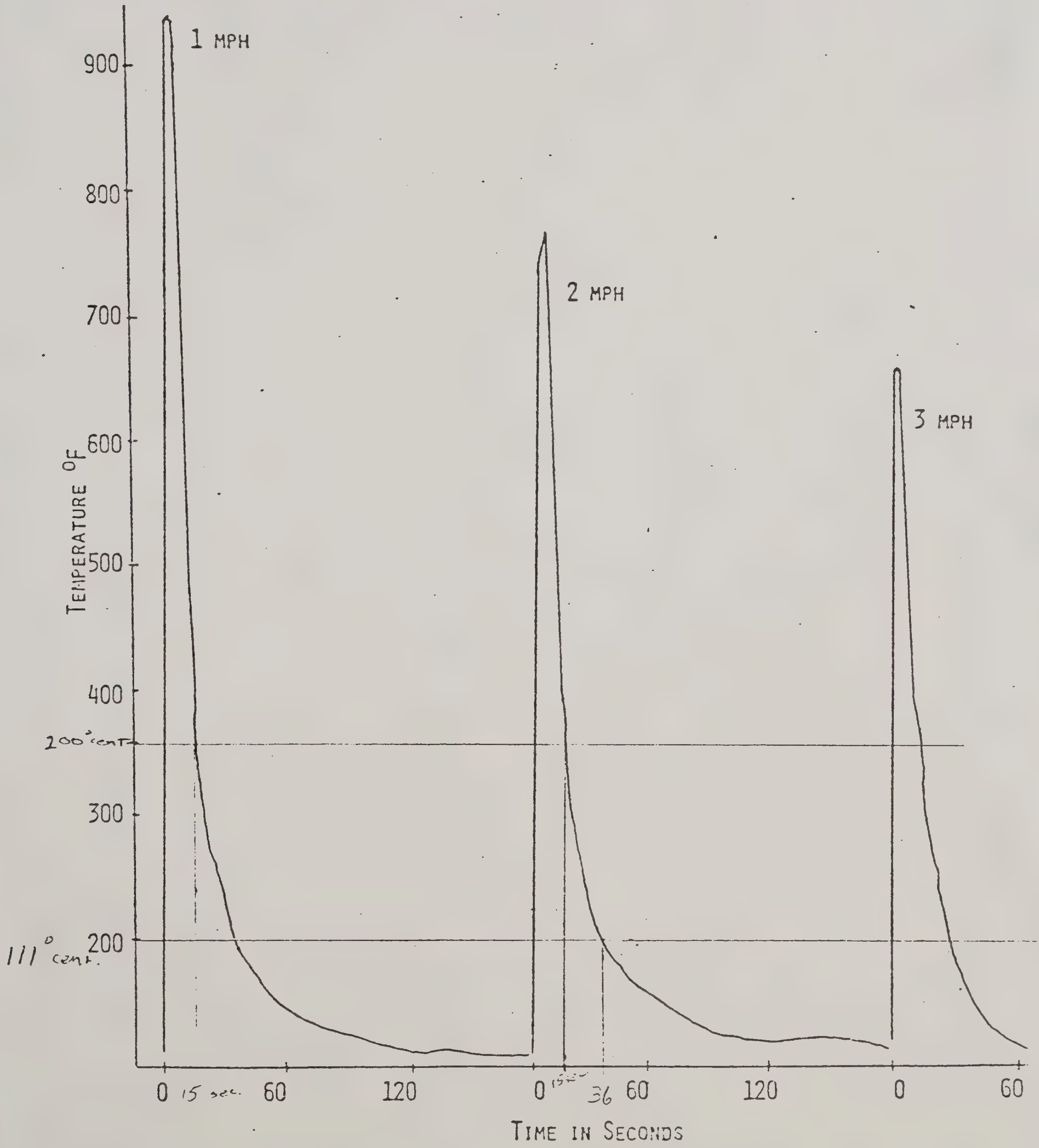
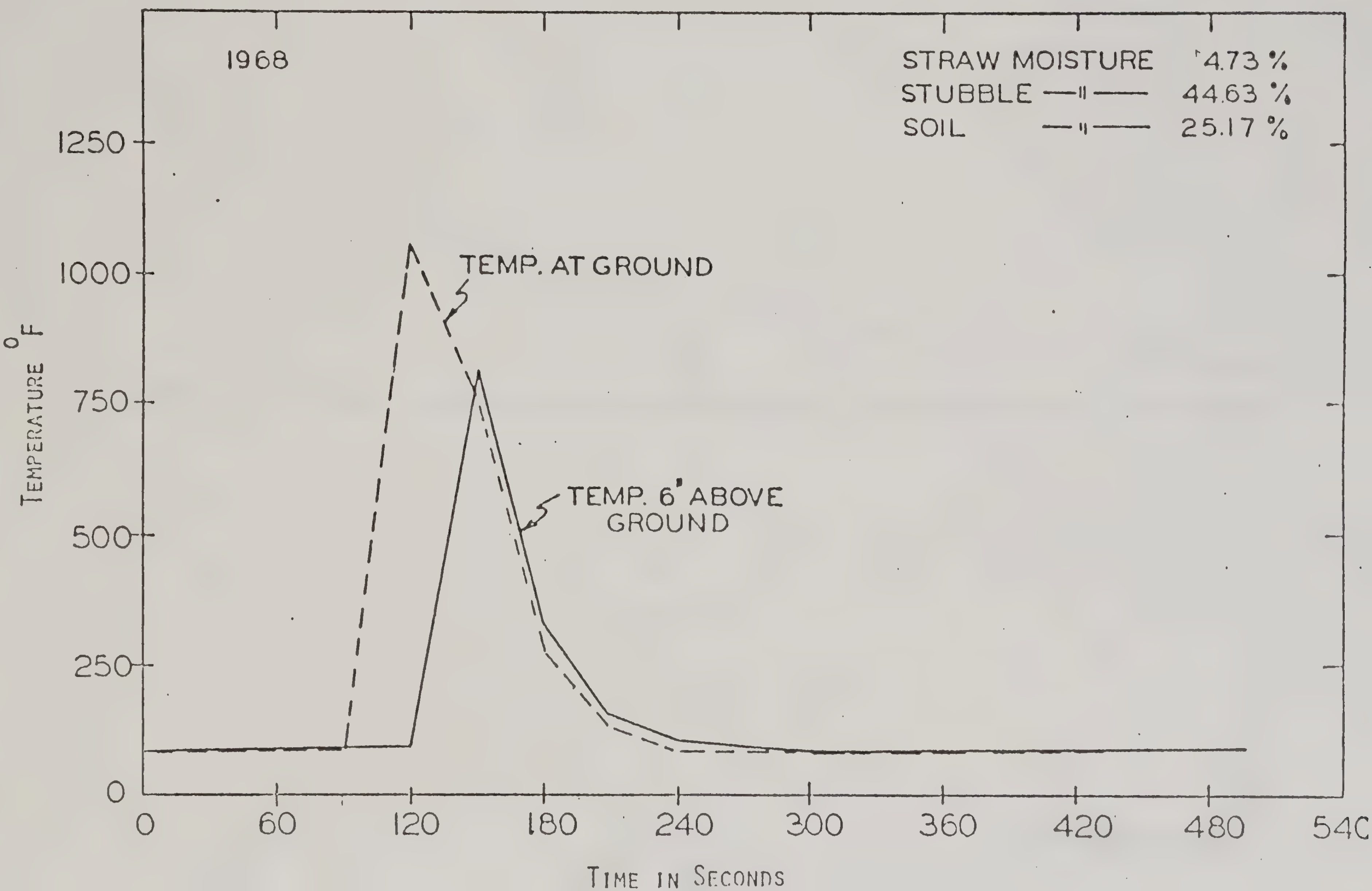
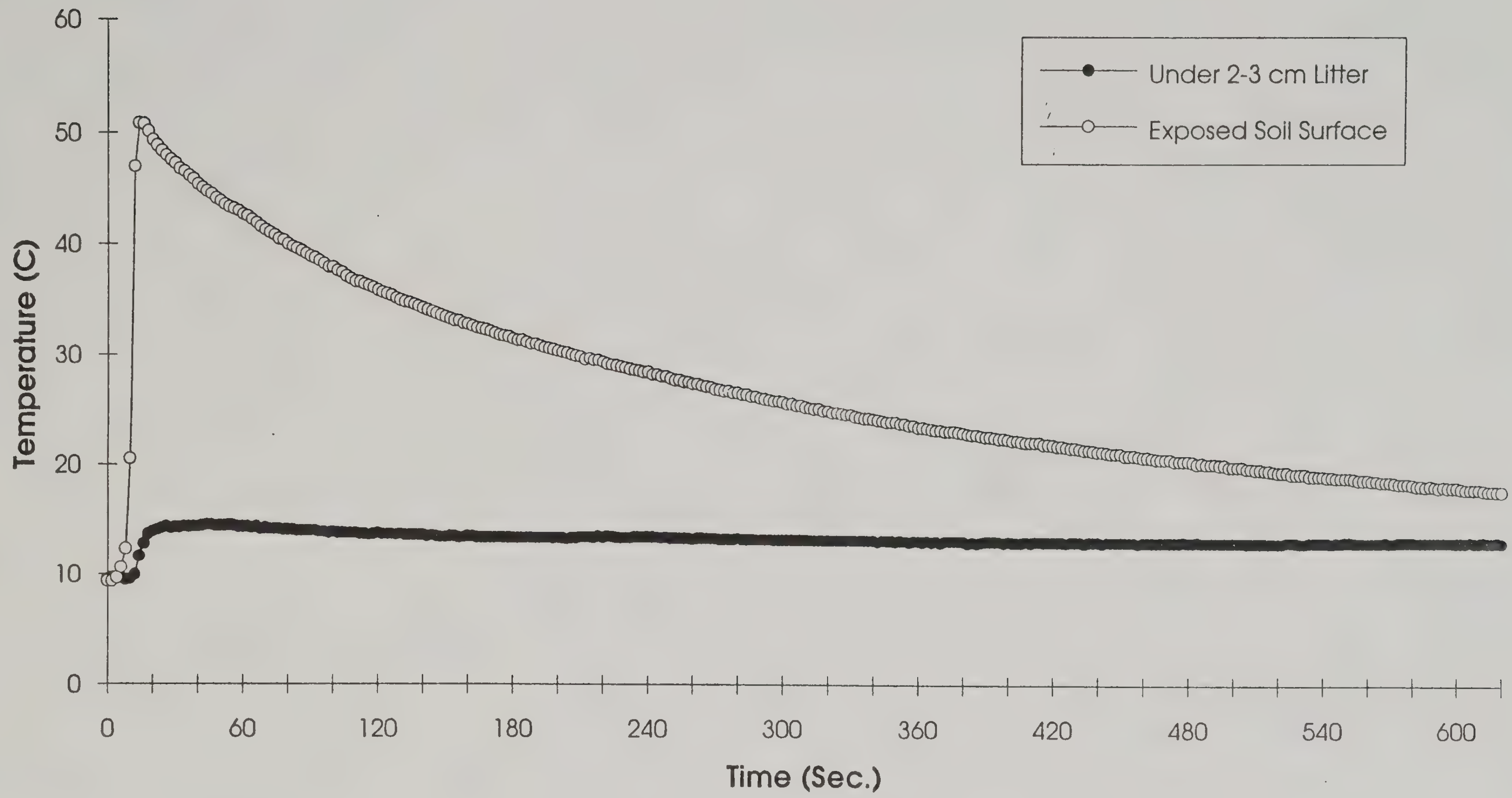


FIGURE 1. COMPARISON OF TEMPERATURE PROFILE AT 1/2" ABOVE GROUND SURFACE FOR PROPANE FLAMER AT VARIOUS SPEEDS OF OPERATION.

Figure 2. Open field burn temperature profiles (Orchardgrass).





Under 2-3 cm Litter
Exposed Soil Surface
Temperature (C)
Time (Sec.)
0
10
20
30
40
50
60
0
60
120
180
240
300
360
420
480
540
600

Trip Report
Site visit to Oconto River Seed Orchard
May 3-4, 1994

Keith Windell, MTDC Project Engineer

INTRODUCTION

As part of the MTDC "Thermal Insect Control" project (TA&S# 3E32P11) Keith Windell traveled to the Oconto River Seed Orchard (Shawno, WI) to inspect a piece of equipment which is being tested for use in lowering populations of white pine cone beetle. The basic idea is to kill the beetle larvae while they are over wintering in cones which are lying on the orchard floor. The thermal treatment uses a liquid propane burning device purchased from Thermal Weed Control Systems, Inc. (Neillsville, WI). A copy of their sales brochure is in the appendix. Evaluation of this concept and machine is being undertaken in a joint effort between Steve Katovich (NA, St. Paul, MN), and Bill Sery (Oconto River Seed Orchard Manager).

BACKGROUND

Steve Katovich wrote the initial test plan (appendix). He had previously consulted Dale Wade (SE, Macon, GA) for input on this approach to the orchards' cone pest problem. Dale said that the mortality temperature for the beetle larvae is about 120 F. He thinks this approach may work but care must be taken to extinguish any ignited sap on the base of the trees. He also thinks that the cones at the base of the trees can be treated by either raking them from the base or using hand held propane torches to light them. Three prior test burns took place in the orchard arboretum beginning in early April. The ground was frozen during the first burn and there was no mortality on the insects. The second burn took place when things were still quite wet. Again, no mortality. The third burn took place when the orchard was very dry. Evidently this burn was successful but the propane burner proved to be an expensive way to light a burn that could have been lit with drip torches. It was mentioned that fire danger was a real concern.

SITE VISIT

The first day I visited the orchard Steve Katovich, Bill Sery, Dick Meier (Regional Geneticist), Dick Cutler (Forest Siviculturist - Nicolet N.F.), Tom Duke & Jim Van Alstine (Wisconsin DNR), and April Schreiber, Dan Rolo, Bill Wesner, Bernie Soquet, and Don Rudie (all ORSO staff) were also in attendance. The

purpose of my visit was to become acquainted with the people involved, the equipment being tested, and the orchard layout.

The orchard is predominantly white and red pine. The infected white pine cones on the orchard floor are about 1/2" wide and 3" long. These cones are closed.

The tractor which pulled the agricultural weed burning unit (or flamer) was a John Deere 2350 (55 hp). The flamer used 8 nozzles mounted on a twelve foot wide tractor tool bar. Although the nozzles were not mounted on the very ends of the tool bar the swath of flame from the flamer was about 12 feet wide.

During my visit we burned a test strip in the arboretum and a 10 acre section. The strip in the arboretum was 600 feet long. Every 200 feet the tractor shifted to the next highest gear. Steve and Bill want to determine how fast they can travel for a given set of conditions and still inflict reasonable mortality.

During the burning of the arboretum I wondered if the flamer was capable of putting out more heat. I telephoned Ron Jones (Thermal Weed Control Systems, Inc.) and spoke to him about the maximum capacity of the equipment. He had preset the regulator to 28-30 psi on his first visit. This is where the flamer is usually operated (fuel consumption at this setting is 10-12 gals/acre when tractor is traveling 2 1/2 - 3 mph). At 30 psi the nozzles should be putting out 500,000 BTU's/hr. according to the sales brochure. The regulator in the system is rated to 40 psi. Don said that we could operate the RTH-001 nozzles at 35 psi but to watch for an erratic flame (puffs) if we try 40 psi. The puffs are due to ignition of a stream of liquid which is not completely vaporized in the nozzles. I tried 40 psi with no puffing present but the pressure gage would occasionally fluctuate above 40. During the 10 acre burn the pressure regulator fluctuated between 35 psi and 40 psi.

When the higher heat setting was first tried a major problem was encountered. The intensity of the flames quickly heat checked four of the propane gas lines and melted some of the electrical wire insulation and a few ignition modules. Several hours were spent modifying the equipment to operate under the higher heat conditions. The nozzles were turned up side down (spark plug and wires were now on top side of nozzle) and faced rearward, an 18" section of metal pipe was inserted between nozzle and rubber hose, a sheet metal shield was installed between the nozzles and the rest of the machine, and ignition wires were replaced. Nozzle angle tested was about 45 degrees to the horizontal and pointed away from the direction of travel. Spacing between nozzles was about 18". Nozzle tips were positioned 4"-5" above the ground.

The first thing burned was the perimeter. Then diagonal rows were burned in a manner to minimize fire escape. Due to our late start the orchard was not completely burned until the next day. The tractor was operated in second gear during the burn (rpm was 1100 rpm the first day and 1500 rpm the second). A total of 245 gallons of liquid propane gas was used to burn the 10 acre section.

Before and after cone samples will be analyzed by Steve Katovich to determine insect mortality. Bill Sery determined cone moisture to be 18% and needle moisture to be 10.8%. A copy of his notes from the test is included in the appendix.

DISCUSSION

Two more test strips will be burned in the arboretum this spring. There are no fall burns planned so far. The success of this insect control approach will be largely known after Steve Katovich analyses the cones. If mortality is high some system refinements may be desirable. If mortality is present but very low options might include:

1. Slowing down the forward speed of the tractor.
2. Adding 4 additional burners (12 total) to the existing system. [This is the maximum number with the current regulator].
3. Installing a 16 burner system from Thermal Weed Control Systems, Inc.
4. Locating nozzles which put out more heat.
5. Designing & building a custom system.
6. Look into other approaches such as steam injection or microwaves.

It should be noted that the idea of a grinder like the one used at Beaver Creek Seed Orchard was discussed. The root systems of the white pines in the orchard are close to the surface and may be damaged by the grinder.

Original Flamer Configuration

Modified Flamer

Appendix

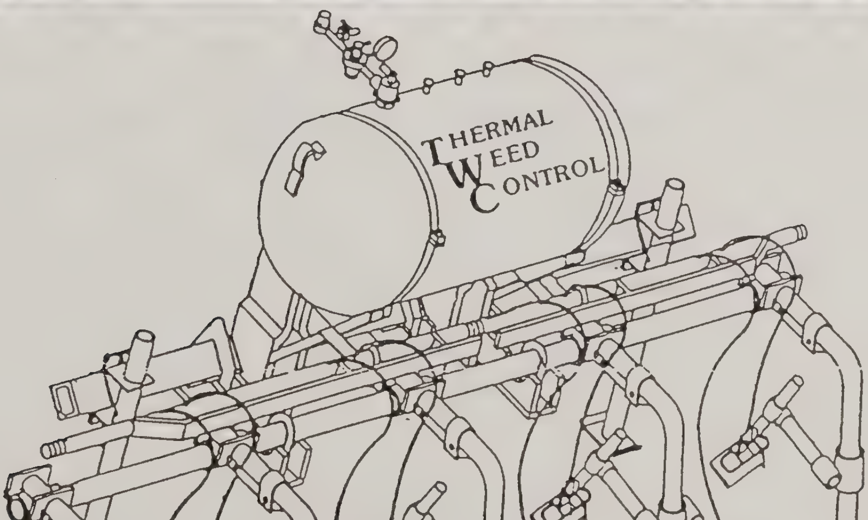
THERMAL WEED CONTROL SYSTEMS, INC.

Route 1, Box 250
Neillsville, Wisconsin 54456
(715) 743-4163

FLAME

WEED CONTROL

for corn, soybeans, potatoes, grain sorgham, onions and others!



SELF VAPORIZING BURNER

RTH-001

Maximum Capacity. . . .500,000 BTU/hr

Normal Operating Pressure. .20-30 PSI

Maximum Fuel Consumption. . .6 gal/hr

RTH-001. . . . . .Wt. 6.25 lbs

This burner, because of its "unique vaporizing capability" has a wide variety of pest control uses. The wide flat burner design allows faster ground speeds for economical row crop operation.

1994 WORK PLAN
OPERATION OF A PROPANE FLAMER FOR WHITE PINE CONE BEETLE CONTROL

Investigators:

Steven Katovich
Insect Ecologist
USDA Forest Service
Northeastern Area, S&PF
St. Paul, MN 55108
(612) 649-5264
DG:S23A

William Sery
Orchard Manager
USDA Forest Service
Oconto River Seed Orchard
Nicolet National Forest
(715) 276-7400
DG:R09F06D04A

Project Location: Oconto River Seed Orchard (ORSO), Nicolet National Forest, Wisconsin.

Project Objectives:

#1 Document the efficacy of a tractor mounted propane flamer for controlling white pine cone beetles in a seed orchard under a range of fuel moisture conditions.

2# Illustrate the propane flamers efficacy and operability under conditions of fuel moisture high enough to prevent ignition of ground fuels.

#3 Illustrate the safety, ease of use and reliability of the propane flamer unit.

#4 Determine the operational cost of the propane flamer in a seed orchard.

Project Description: This project will basically consist of two components. First, a series of plot trials done in the white pine breeding arboretum at ORSO and a second component being an operational test of the burner in the white pine orchard at ORSO.

<u>Plot Trials</u> - Plots, or treatment blocks, would be located in the arboretum, and treated with the propane flamer. The basic goal would be to compare efficacy of the flamer against overwintering cone beetles and to investigate any fire behavior at different fuel moisture levels. Treatment blocks would be treated at several different times during the window for controlling beetles in cones (early April - mid-May), in an attempt to examine a range of fuel moisture regimes. Treatments considered would include early morning and evening treatments, Treatments done at different tractor speeds and treatments following rain or snow. The goal would be to illustrate the burners efficacy under conditions of fuel moisture high enough to prevent ignition of ground fuels.

Operational Trial - The white pine seed orchard would be operationally treated with the propane flamer during the spring, 1994. The goal would be to document the cost of operating the flamer compared to insecticide applications that were applied in 1992 and 1993.

Equipment and Materials Needed:

Propane Flamer - Purchased by the Forest Service, Northeastern Area, Forest Health protection unit, in 1993. Currently housed at the Oconto River Seed Orchard.

Tractor with a 3-Point Hitch - Available from the seed orchard.

Equipment and instruments to measure fuel moisture and document fuel load - Source to be determined by the "Burn Plan" developed for the project.

Fire Suppression Equipment - Needs and source to be determined by the "Burn Plan" developed for the project.

Methods:

Plot Trials

Treatment Blocks: Block size will be 100 ft. by 40 ft. Blocks will be randomly located in the breeding arboretum at ORSO. Blocks will be located and marked in early April by the principal investigators. On each block, pre-burn data collection will occur just prior to treatment and will include:

Data Requirement	Person Responsible
Location of all infested cones [1]	Katovich
Fuel load and fuel type	Sery and Katovich
Fuel Moisture Content	Sery and Katovich
Burning Conditions, RH, Wind, etc.	Sery and Katovich
Photographic record of pre-burn conditions	Katovich

[1] A minimum of 30 cones will be required on each treatment block. If 30 cones are not present, additional cones collected outside the block will be seeded onto the treatment area.

On each treatment date, a minimum of 50 cones in areas in the vicinity of treatment blocks, but not subjected to the propane flamer, will be collected, dissected and live and dead beetles determined. This will provide a control to compare against the treated cones.

Information collected during the treatment will include:

Data Requirement	Person Responsible
Tractor speed	Sery
Fire behavior in plot fuels	Sery

Post-burn data collected will include:

Data Requirement	Person Responsible
Collection and dissection of all infested cones in the treatment area	Katovich
Monitoring of fire behavior in plot fuels for 24 hours	Sery
Long-term monitoring of plots to document any tree root damage	Sery
Photographic record of post-burn conditions	Katovich

Operational Trial

Information collected from the seed orchard at ORSO prior to treatment will include:

Data Requirement	Person Responsible
Fuel load, fuel type, fuel moisture content	Sery and Katovich
Burning conditions, RH, Wind, etc.	Sery
Location and marking of infested cones	Katovich
Collection and dissection of a subsample of infested cones (Treatment Check)	Katovich

Information collected during the operation will include:

Data Requirement	Person Responsible
Timing of length of application	Sery
Tractor fuel use	Sery
Tractor speed	Sery
Fire behavior in the orchard	Sery

Post-burn data collection will include:

Data Requirement	Person Responsible
Collection and dissection of infested cones in the orchard	Katovich
Monitoring of cone beetle impact in the orchard in 1994	Katovich

Data Analysis and Reports: The data collected will be summarized and a report developed for the June, 1994, meeting of the Cone and Seed Working Group, in Rhinelander. A field trip to ORSO and discussion of the information will also occur at that meeting.

MESSAGE SCAN FOR KEITH WINDELL

To S.KATOVICH:S23A
To K.WINDELL:R01A
CC D.MEIER:NIC
CC .CUTLER:NIC

From: BILL SERY:R09F06D04A
Postmark: May 10,94 1:49 PM Delivered: May 10,94 12:48 PM

Subject: ORCHARD 3 BURN

Comments:
STEVE & KEITH. I wrote up the notes for our burn last week just so we won't lose anything.

---------------X---------------

BURN OF ORCHARD 3 - PRODUCTION ORCHARD
OCONTO RIVER SEED ORCHARD

;re

.te 5-3-94 Time 0830-0900 1530-1930

Steve Katovich	- SP&F		
Keith Windell	- MTDC		
Dick Meier	- Lake States NF's	(0830-0900)	
Dick Cutler	- Nicolet SO	(0830-0900)	
Tom Duke	- WDNR		
Jim Van Alstine	- WDNR		
Bill Sery	- ORSO		
April Schreiber	- ORSO		
Dan Rolo	- ORSO		Fire Watch Until 2200
Bill Wesner	- ORSO		Dan Rolo
Bernie Soquet	- ORSO	SCSEP	Bill Wesner
Don Rudie	- ORSO	SCSEP	

Date 5-4-94 Time 0900-1600

Keith Windell	- MTDC	(0800-1130)	
Tom Duke	- WDNR	(0800-1130)	
Bill Sery	- ORSO		
April Schreiber	- ORSO		
Dan Rolo	- ORSO		Fire Watch until 1900
Bill Wesner	- ORSO		Dan Rolo
ernie Soquet	- ORSO	SCSEP	Bill Wesner
on Rudie	- ORSO	SCSEP	

Equipment on Burn

Tractor-mounted propane burner with 8 burners
Bulldozer with fire plow and spray system (WDNR)
Truck mounted pumpers. 1 WDNR 1 FS
Tractor with fireplow.
Handtools: Swats, shovels, pulaskis, rakes, etc.

Burn Notes

A perimeter burn was started on the south side of Orchard 3 at about)830. The intent was to burn a perimeter around the orchard to act as a fireline and then burn the middle. Temperature was about 50^{o}F, humidity - 75%, and winds picking up from the south. The propane pressure was increased to 35-40 psi to produce a better burn. After burning about 1/2 of the south side, some tape was noted to be melting on the propane lines so the burner was shut down and inspected. It was discovered that some of the gas hoses had been severely heat-checked. Insulation on wires and the manifold had been melted.

.he unit was taken back to the shop for revamping. Angle of the burners ·ere directed backwards. Four checked gas lines were replaced. The metal ›ropane pipes extending from each burner were extended by adding 18 inch black ›ipe nipples. This moved rubber gas lines further away from the fire. Wires 'rom the electronic ignition were replaced, and a sheet metal shroud was built .n front of the burners. The system was checked for leaks prior to ignition :esting.

At about 1530 on 5-3-94, the burn was restarted in orchard 3. Temperature ·as 65-70°F, humidity was lower than in the morning, and wind was blowing 'rom the S - SW. Some difficulty was experienced at the NW corner of the ›rchard where a pile of needles was located in the forest close to the burn ırea. Quick action by tanker, dozer, and ground personnel was able to control :he situation.

After the perimeter was burned, alternate rows were burned on a diagonal .n a SE-NW direction. Fire slowly creeped through many areas and up to the ›ase of many trees. Fire started to ignite pitch streams on some tree trunks. :hese were quickly doused with backpack sprayers. Burning was stopped at 1930 ›n 5-3-94, and a fire watch was maintained until 2200.

Burning was continued at 0900 on 5-4-94. Conditions were much the same as :he previous day except the humidity was increasing due to an approaching storm :r Non-burned rows in a SE-NW direction were burned. Then rows in a SW-NE ìi ion were burned. This meant that the orchard was criss-crossed in two ìirections. After burning, at least 95% of the orchard had been blackened. 4uch of the orchard hard been exposed twice to the intense heat of the burner. \ fire watch was maintained until 1900 on the second day.

Before and after burn cone samples were collected and taken to St.Paul for ınsect analysis by Steve Katovich. Samples of cones and needles were taken for ıoisture analysis. The moisture test results were as follows:

Cones:	Wet Weight -	126.0gm
	Dry Weight -	106.8gm
	% Moist. OD -	18.0%
Needles:	Wet Weight -	80.9gm
	Dry Weight -	73.0gm
	% Moist. OD -	10.8%

ımount of Propane Used

1st tank	5/3/94	80 gal.
2nd tank	5/4/94	85 gal.
3rd tank	5/5/94	80 gal.
	Total	245 gal

With the exception of the near meltdown, the burning went as planned. The cones were exposed to a zone of intense heat of about six feet behind the burner. This was followed by an zone of more moderate heat of 50-100 feet which consisted of burning fine fuels. After this area passed, fire crept around in fine fuels in the burner swath and to both sides exposing even more cones to some degree of heating. It is clear that the intensity and completeness of burning could not have been accomplished using drip torches.